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## Health benefits of vegetables

**Ramya V and Priya Patel**

### Abstract

Vegetables are indispensable for equilibrated diets since they contribute a crucial source of nutraceuticals in daily human life. The nutraceuticals are the substances found as a natural component of foods or other ingestible forms that have been determined to be beneficial to the human body in preventing or treating one or more diseases or in improving physiological performance beyond adequate nutritional affects in a way that is relevant to either improved stage of health and well-being and reduction of risk of disease. These components can be beneficial antioxidants, natural colorants (e.g. carotenoids), minerals, vitamins, which often have added advantages. The promotion of healthy vegetable products has coincided with a surging consumer interested in the healthy functionality of food. Each vegetable comprise a unique combination of phyto nutraceuticals which differentiate them from other vegetables. Vegetable intakes have been highly correlated with improved gastrointestinal health, reduced risk of heart attack, some types of cancer and chronic ailments such as diabetes. This chapter makes a review and discusses the health benefits of commonly used vegetables.

**Keywords:** antioxidants, chronic ailments, health benefits, phyto nutraceuticals, vegetables

### Introduction

Vegetables contribute a major source of nutraceuticals for well-balanced human diet. The nutraceuticals are the substances found as a natural component of foods or other ingestible forms that have been determined to be beneficial to the human body in preventing or treating one or more diseases or in improving physiological performance beyond adequate nutritional affects in a way that is relevant to either improved stage of health and well-being and reduction of risk of disease. These components can be beneficial antioxidants, natural colorants (e.g. carotenoids), minerals, vitamins, which often have added advantages [1]. While the nutritional importance of vegetables has long been recognized within the nutrition and medical communities, there is an increasing awareness among the general public of the health advantages of diets high in vegetables.

Vegetables are grown worldwide in almost 200 countries and make up a major portion of the diet of humans in many parts of the world. Wide range of climate and physio-geographical conditions around world ensures availability of most kind of vegetables. Total vegetable production in the world has been estimated to be 486 metric tons, respectively [2]. India is the second largest producer of the vegetables (176.177 Million tonnes) in the world [3]. Many vegetable commodities meet human caloric demands because of the carbohydrates they contain, and legume crop are especially valuable source of essential amino acids. Leafy and other vegetables are also good suppliers of vitamins, minerals and dietary fiber. Vegetables can play an even more important role in the nutritional quality of diets. This can be accomplished through better dissemination about their nutritional value and through changes in eating habits that will benefit people, especially those on marginal diets. Nevertheless, vegetable production in developing countries, unfortunately, often takes a secondary role to high-calorie grain crops [2].

A high vegetable diet has been associated with lower risk of cardiovascular disease in humans [4]. Low vegetable intake, in unbalanced diets, has been estimated to cause about 31% of ischaemic heart disease and 11% of stroke worldwide. According to the 2007 World Health Report unbalanced diets with low vegetable intake and low consumption of complex carbohydrates and dietary fiber are estimated to cause some 2.7 million deaths each year, and were among the top 10 risk factors contributing to mortality [5, 6]. The exact mechanisms by which vegetable consumption reduces human diseases have not yet been fully understood, however the general consensus among physicians and nutritionists is that phyto nutraceuticals reduce the risk of chronic diseases such as cancer.

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In many areas of the world, increased consumption of vegetables has been stimulated by a growing apprehend of the health implications of diets high in vegetables, along with an increasing variety of vegetables for consumption. A world survey showed that at least 402 vegetables are cultivated and commercialized worldwide<sup>[5, 9]</sup>. They represent 69 families and 230 genera. From these great diversity leafy vegetables comprised 53% of the total, followed by fruits vegetable (15%), and roots and tuber vegetables (17%). Most of the vegetables are perishable and marketed fresh with only a small proportion processed. Consumption shortly after harvest guarantees optimal vegetable quality. Vegetables not only provides calorie but also in all their many forms ensure an adequate intake of most vitamins and nutrients, dietary fibers, and phytochemicals which can bring a much needed measure of balance back to diets contributing to solve many of these nutrition problems in both a quantity and a quality issues.

Increased consumption of fruits and vegetables has been associated with protection against various age-related diseases<sup>[13]</sup>. Vegetable consumption is also rising, reflecting the consumer's increased income, desire for diversity, and awareness of nutritional benefits. At the same time, consumers have a rising concern with product safety issues. The promotion of healthy vegetable products has coincided with a surging consumer interested in the healthy functionality of food. There is an increasing awareness among the general public of the advantages of diets rich in vegetables to ensure an adequate intake of most vitamins and micronutrients, dietary fibers, and phytochemicals that promote health.

To facilitate change in consumer behaviour for increasing consumption of fruit and vegetables, a wide variety of health, promotional and social marketing interventions have been conducted around the world for more than a decade. However, the success of these initiatives, measured in terms of increase in daily consumption per person per serve, remains modest. Overall, it can be safely stated that, there is an increasing awareness among the general public of the advantages of diets rich in vegetables to ensure an adequate intake of most vitamins and micronutrients, dietary fibers, and phytochemicals that promote health. Therefore there is a need to select vegetables which are rich in phytochemicals and enhanced level of nutraceuticals. This chapter makes a review and discusses the health benefits of commonly used vegetables.

## 2. Health benefiting properties of vegetables

The importance of vegetables and fruits in the human diet has been recognized by the World Health Organization (WHO), which promotes and recommends the consumption of at least 400 g of vegetables and fruits per day to provide the optimum health and necessary nutrients lacking in other food groups<sup>[6]</sup>. The epidemiological evidence for the benefit of consuming diet that is high in fruit and vegetables is quiet compelling. The evidence of specific vegetables and indeed specific compounds is less convincing, although epidemiological studies of cancer suggest that it is mainly the highly colored green or yellow vegetables that are associated with reduced incidence and mortality rates<sup>[7]</sup>. Vegetables in the daily diet have been strongly associated with overall good health, improvement of gastrointestinal health and vision, reduced risk for some forms of cancer, heart disease, stroke, diabetes, anaemia, gastric ulcer, rheumatoid arthritis and other chronic diseases<sup>[5, 8]</sup>.

Some efforts to increase nutrient intake have been made by biofortification and nutrient supplementation. A Bio fortifying staple crop is increasingly used as a complementary strategy for combating micronutrient malnutrition among the poor in developing countries<sup>[14]</sup>. Maize (*Zea mays* L.) biofortified with  $\beta$ -carotene and rice (*Oryza sativa* L.) biofortified with iron or  $\beta$ -carotene are examples of efforts to increase micronutrient uptake in staple-heavy diets. Supplements are commonly available in developed countries and can be used to provide the required micronutrients among populations with nutrient deficiencies in developing countries but at a relatively high cost<sup>[8]</sup>. The consumption of fresh vegetables gives the consumer a variety of compounds that have a positive influence on human health. The phytochemicals found in fresh vegetables have anti-inflammatory, enzyme inhibiting and bioactive features capable of combating the activities of oxidants. Until few years ago it was believed that 14 vitamins and 16 essential minerals were the key for human nutrition and health. Recently, with the developments in chemistry, it was found that vegetables contain thousands of beneficial phytochemicals in addition to the 14 vitamins and 16 minerals. Some phytochemicals are robust antioxidants and are believed to reduce the risk of some chronic ailments<sup>[9, 10]</sup>. Phytochemicals are organic compounds derived from plants which have best health protective effect as well as disease protection and regression. Besides the common nutrients such as carbohydrates, amino acids and protein, there are certain non-nutrient phytochemicals in vegetables that have biological activity against chronic diseases. They are low in fat and like all plant products, contain no cholesterol. Most phytochemicals are found in relatively small quantities in vegetable crops. However, when consumed in sufficient quantities, phytochemicals contribute significantly towards protecting living cells against chronic diseases<sup>[10-12]</sup>. Vegetable intake has been highly correlated with improved gastrointestinal health and reduced risk of heart attack, some types of cancer and chronic ailments such as diabetes<sup>[9, 15]</sup>. Hence, consumption of a vegetable rich diet regularly has undeniable positive effects on health and is likely to afford better protection against several chronic ailments. The exact mechanism by which vegetable consumption reduces human diseases have not yet been fully understood, however research over the last 2 decades has provided a scientific basis to support the common wisdom that consuming fresh vegetables containing compounds such as phytochemicals may contribute to the overall health benefit. For example the dietary fiber content contribute to the health benefit by improving bowel transit, by helping manage blood glucose concentrations, and by transporting through the human gut a remarkable amount of phyto nutraceuticals and minerals linked to the fiber matrix<sup>[9]</sup>. Another example is that, high consumption of tomatoes and tomato products has been linked to carcinogenesis reduction, especially regarding prostate cancer. This has been linked to lycopene, which gives tomatoes their red colour<sup>[16]</sup>. Whole foods are increasingly seen to be more beneficial to human health than isolated components such as supplements. There are also suggestions that antioxidants in vegetables may reduce risk of certain cancers. Increased consumption of carotenoid rich vegetables outperforms carotenoid dietary supplements in increasing low-density-lipoprotein oxidation resistance, lowering DNA damage and inducing higher repair activity in human volunteers<sup>[17]</sup>. The negative effect of radio and chemotherapies can be overwhelm by adding vitamins A, C and E dietary supplements to the diet of cancer patients<sup>[18]</sup>.

The most important phyto Nutriceuticals in vegetables that have biological activity against chronic diseases are: vitamins, minerals, dietary fiber, antioxidants, carotenoids and flavonoids.

### 2.1 Vitamins

The term vitamin is derived from the words vital and amine. A healthy body needs vitamins and was originally thought to be amines but not all vitamins are amines. They are essential for normal body functions, cell function regulation, growth and development. Vitamins must be obtained from the diet, as the body cannot produce them in adequate amounts. Citrus fruits, strawberries, green peppers, tomatoes, and kiwi are examples of foods high in vitamin C [10]. All vegetables are sources of vitamins and consequently have health benefits. Vitamins such as A, B6, C and K are important to the human body and can be provided by vegetables [15, 18].

### 2.2 Minerals

Minerals are inorganic substances that are originally found in rocks and soil. The vegetables have plenty of minerals which are required by the body for growth and also have certain health benefits. Minerals can be divided into two groups. Major minerals, macronutrients, with a high prevalence of inadequate intake in worldwide diets include calcium, magnesium, and potassium. Trace minerals, micronutrients, identified as nutrients with great health implications and benefits, usually with a high prevalence of inadequate intake, include iron, zinc and selenium [15].

Calcium plays an important role in building stronger, denser bones early in life and keeping bones strong and healthy later in life [19]. Magnesium is needed for bone, protein, making new cells, activating B vitamins, relaxing nerves and muscles, clotting blood, and in energy production [20]. Potassium ions are necessary for the function of all living cells. It is essential for the body's growth and maintenance [21]. Iron plays an important role in human health, forming complexes with molecular oxygen in hemoglobin and myoglobin [22]. Dried beans, lentils, peas, as well as all the other legumes, and dark green leafy vegetables are especially good sources of iron, even better on a per calorie basis than meat. The World Health Organization advocates zinc supplementation for severe malnutrition and diarrhea [23]. Zinc supplements help to prevent disease and reduce mortality, especially among children with low birth weight or stunted growth. Zinc is found in vegetables such as beans, peas, pumpkin seeds, sea vegetables, and in nuts, almonds, whole grains, sunflower seeds, soy foods and black currant. Selenium is an essential trace element that is involved in the defense against the toxicity of reactive oxygen species, the regulation of the redox state of cells and in the regulation of thyroid hormone metabolism [24, 25]. The antioxidant properties of selenoproteins help prevent cellular damage from free radicals.

### 2.3 Dietary fiber

Dietary fibres is a heterogeneous mixture mostly include non-starch polysaccharides (NSP) such as celluloses, hemicelluloses, gums and pectins, lignin, resistant dextrins and resistant starches [25] which are indigestible in the small intestine. Some excellent sources of soluble fiber are kidney beans, barley, bran-rich breakfast cereals, and baked potatoes with skin, spinach, oatmeal, and popcorn. Foods rich in fiber satisfies hunger without contributing excessive calories thus aids weight loss [26], improves serum lipoprotein values [27],

lowers blood pressure level [29] and controls blood glucose level [9, 28]. Research reveals that certain soluble fibres may help to enhance the immunity in humans [30] and prevents colon cancer and other types of cancer [15]. Most health agencies recommend that adults should consume 20-35 grams of fiber daily [10]. An average of five servings of fruits and vegetables a day and regularly include whole grain breads, cereals, and legumes in diet may fulfill the requirement.

### 2.4 Antioxidants

Antioxidants protect the body from adverse biological reactions involving oxygen. Antioxidants counteract or neutralize the harmful effects of free radicals. These act as scavengers for free radicals and reactive oxygen species, thereby preventing them from disrupting the chemical stability of the cells. Fortunately the body has a natural defense system against cellular damage by free radicals, which comprise primarily of antioxidant nutrients (e.g., vitamin E, vitamin C, and certain carotenoids), which are assisted by a variety of phyto-chemicals from the diet. Vitamins, minerals, and phytochemicals contained in fruits and vegetables each have antioxidant activity. Orange and yellow fruits and vegetables, as well as green leafy vegetables, are rich sources of carotenoids. Good sources of vitamin E include nuts and seeds, wheat germ, and vegetable oils. With the exception of vitamin E, these antioxidants are widely distributed in fruits and vegetables [10]. They have been investigated for their specific role in the prevention of cancers, heart disease, eye disease and other human health conditions [17, 18].

### 2.5 Carotenoids

Carotenoids are a class highly pigment which is responsible for yellow, orange and red color in fruits and vegetables. Carotenoids like lycopene,  $\beta$ -carotene, lutein, zeaxanthin are known to be the most efficient singlet oxygen quencher in the biological systems without the production of any oxidizing products.  $\beta$ -carotene traps peroxy free radicals in tissues at low oxygen concentrations. Hence  $\beta$ -carotene complements the antioxidant properties of vitamin E [25]. For optimal absorption in the human body, they are best consumed when cooked with a little fat. In the diet they act as powerful antioxidants and are believed to protect the body against free radical attack and hence reduce the incidence of cataracts, heart disease, eye disease and certain cancers [10, 18].

### 2.6 Flavonoids

A largest group of antioxidant phyto Nutriceuticals, termed flavonoids present in fruits and vegetables. There are more than 4,000 secondary plant metabolites in the flavonoid family. Flavonoids are further classified into anthocyanins, flavonols, flavones, and isoflavonoids [15]. It is attributed to the fact that high intake of flavonoid rich foods has been advanced in the protection against diseases, such as cancer and also reduces the risk of cardiovascular disease [13, 18]. Anthocyanins are one of the largest and most important groups of water-soluble pigments in most species in the plant kingdom. Anthocyanins give vegetable leaves and fruits their purple and/or red colour appearance, such as in eggplant, red cabbage, purple and black broccoli, red onion, beet, rhubarb, purple and red-skinned potato, purple sweet potato, purple corn, red lettuce, red endive, red radish, strawberry, etc. [32-35]. These pigments may reduce the risk of coronary heart disease through inhibition of platelet aggregation [18, 36]. Flavonols include quercetin, kaempferol, fisetin, myricetin, and rutin.

Quercetin is one of the most widely distributed flavonoids in the human diet, found in apples, onions and citrus fruits. It may have antioxidant and anti-inflammatory activity [10, 18]. Evidence obtained with an in vitro oxidation model for heart disease has demonstrated that several plant flavonols, such as quercetin, myricetin and rutin, are more powerful antioxidants than the traditional vitamins [15]. So there are grounds for encouraging the consumption of vegetables and other foods rich in flavonols. Flavones include apigenin and luteolin. Flavones have been detected in conjugated form in celery, tomato, brinjal, garlic and onion [10]. In recent years, scientific and public interest in flavones has grown enormously due to their putative beneficial effects against atherosclerosis, osteoporosis, diabetes mellitus and certain cancers [15]. The mechanism action of flavones on chronic diseases is similar to that of other flavonoids. Isoflavonoids including daidzen, genistein, and glycitein have limited distribution in vegetables. They exist mainly in legumes including soybean, lentil and chickpea. Small quantities have been detected in vegetables such as broccoli, asparagus, alfalfa sprouts, okra and mushrooms [10, 15]. Isoflavones have received considerable attention as potentially preventing and treating cancer and osteoporosis [31].

### 3. Commonly consumed vegetables and their benefits

The main Constituents of fruits and vegetables that have a positive impact on human health and their sources are given in Table 1. The health benefit of vegetables should not be linked to only one compound or one type of vegetable, but a group of vegetable that provide better protection against certain chronic diseases. The main difference is that each vegetable group contains a unique combination of phyto Nutriceuticals, which distinguishes them from other group of vegetables. The most commonly consumed vegetables such as crucifer, allium and solanaceous vegetables.

Cruciferous vegetables includes cabbage, Broccoli, cauliflower, Brussels sprouts, kales, Kailan, Chinese cabbage, turnip, rutabaga, radish, horseradish, rocket, watercress, mustards, among other vegetables, provide the richest sources of glucosinolates in the human diet [41]. Dias [15] mentioned that a diet rich in crucifers is likely to protect humans against colon, rectum, and thyroid cancers, and when consumed with vegetables rich in other phyto Nutriceuticals, can protect against cancer in other organs.

Alliums vegetables (*Alliaceae family*) include, garlic, onion, leek, chive, Welsh onion, among other vegetables. They are

rich in a wide variety of thiosulfides, which have been linked to reducing various chronic diseases. Solanaceous vegetables includes tomato, potato, egg plant, sweet and hot pepper. Tomato is a good source of lycopene, folate, vitamin C, vitamin A and vitamin E and widely grown vegetable in the world after potato. Tomatoes, with their distinctive nutritional attributes play an important role in reducing the risk of cardiovascular diseases, several types of cancers and associated diseases [18, 39, 40]. Potato is perceived only as a source of carbohydrates, but is also an excellent source of essential amino acids. It is said to give protection against colon cancer, improves glucose tolerance and insulin sensitivity, lowers plasma cholesterol and triglyceride concentrations, increases satiety, and possibly even reduces fat storage [42]. The eggplant is a popular vegetable crop grown in many countries which is also known as brinjal in south Asia. Eggplant is an excellent source of digestion-supportive dietary fiber and bone-building manganese, enzyme-catalyzing molybdenum and potassium. Eggplant is also a good source of bone-building vitamin K and magnesium as well as copper, vitamin C, vitamin B6, folate, and niacin. Eggplant is also effective in the treatment of high blood cholesterol [37]. Peppers are excellent sources of vitamins C, carotenoids and flavonoids [38]. Antioxidant vitamins A and C help to prevent cell damage, cancer and diseases related to aging, and they support immune function. They also reduce inflammation like that found in arthritis and asthma. Vitamin K promotes proper blood clotting, strengthens bones, and helps protect cells from oxidative damage [15].

### 4. Conclusion

With the ever-changing lifestyle of humans, the antioxidant defense systems are often overloaded resulting in oxidative stress. Moreover, the levels of antioxidant defense mechanism decrease appreciably with age. These may result in the development of a great many diseases. Hence, a regular consumption of vegetable-rich diet has undeniable positive effects on health since phyto nutraceuticals of vegetables can protect the human body from several types of chronic diseases. The mechanism by which vegetables decrease risk of disease is complex and largely unknown but various components of the whole food are likely to contribute to the overall health benefit. Finally it can be concluded that health benefits can be improved by increased consumption of vegetables as it contains vast phytochemicals which may be an important source of dietary antioxidants.

**Table 1:** Constituents of fruits and vegetables that have a positive impact on human health and their sources

Nutrient	Function in the Body	Fruit and Vegetable Sources	Impacted human diseases
Vitamin A	Essential for vision, skin and the immune system. Promotes growth. Protects against some types of cancer.	Cantaloupe, apricots, dark green and deep yellow vegetables such as pumpkin, carrots, sweet potatoes, spinach, greens and bell peppers.	Cancer, cataracts, heart disease, stroke
Vitamin C	Strengthens blood vessels, improves wound and bone healing, increases the resistance to infections and increases the absorption of iron – another important nutrient for growth.	Cantaloupe, honeydew melon, peaches, oranges, strawberries, kiwifruit, asparagus, sweet potatoes, bell peppers, broccoli, Brussels sprouts.	
Vitamin E	It is the major lipid-soluble component in the cell antioxidant defence system and is exclusively obtained from the diet. Oxidation has been linked to numerous possible conditions and diseases including cancer, ageing, arthritis and cataracts.	Nuts (such as almonds, cashew nuts, filberts, macadamias, pecans, pistachios, and walnuts)	
Antioxidants and	Antioxidants are vitamins, minerals and other substances that fight free radicals, which play a role in the progression	Fruits and vegetables bursting with color such as berries, tomatoes, and	cancers, heart disease, eye disease and other

Phytonutrients	of cancer and heart disease. Phytonutrients are the color pigments in the fruits and vegetables that either act as antioxidants or enhance the antioxidant benefits.	dark green and deep yellow vegetables.	human health conditions
Fiber	Important to maintain digestive health, as well as reduce blood cholesterol.	Raspberries, peas, blackberries, Brussels sprouts, parsnips, raisins, broccoli, black beans.	Diabetes, heart disease
Folate	Important for normal cell division, wound healing and prevention of birth defects.	Orange, dried peas and beans, green leafy vegetables such as mustard and turnip greens, collards and spinach.	Birth defects, cancer, heart disease
Calcium	Important for strong bones, blood clotting, muscle contraction and nerve function.	Rhubarb, okra and green leafy vegetables such as mustard and turnip greens, collards, kale and spinach.	building stronger, denser bones early in life and keeping bones strong
Potassium	Potassium provides the "yin" to sodium's "yang." It lowers your blood pressure and also protects you from blood pressure increases after consuming sodium.	Baked potato or sweet potato, banana & plantain, cooked dry beans, cooked greens, dried fruits (such as apricots and raisins), winter (orange) squash	Hypertension, stroke

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