

Nutritional Wealth of Vegetables in Human Diet: A Review

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Abstract—Vegetables are considered essential for well balanced diets since they supply vitamins, minerals, dietary fiber, and phytochemicals. Each vegetable group contains a unique combination and amount of these phytonutriceuticals, which distinguishes them from other groups and vegetables within their own group. In the daily diet vegetables have been strongly associated with improvement of gastrointestinal health, good vision, and reduced risk of heart disease, stroke, chronic diseases such as diabetes, and some forms of cancer. Some phytochemicals of vegetables are strong antioxidants and are thought to reduce the risk of chronic disease by protecting against free radical damage, by modifying metabolic activation and detoxification of carcinogens, or even by influencing processes that alter the course of tumor cells. All the vegetables may offer protection to humans against chronic diseases. Nutrition is both a quantity and a quality issue, and vegetables 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. The promotion of healthy vegetable products has coincided with a surging consumer interest in the healthy functionality of food. Because each vegetable contains a unique combination of phytonutriceuticals, a great diversity of vegetables should be eaten to ensure that individual's diet includes a combination of phytonutriceuticals and to get all the health benefits. This article makes a review and discusses the nutritional quality and health benefits of the major groups of vegetables. More interdisciplinary work is required that involves nutritional and food scientists as well as others from biomedical fields to ascertain the throe function of specific phytonutriceuticals.

Keywords: Antioxidants; Dietary Fiber; Phytochemicals; Phytonutriceuticals; Vegetables

1. INTRODUCTION

Vegetables make up a major portion of the diet of humans in many parts of the world and play a significant role in human nutrition, especially as sources of phytonutriceuticals: vitamins (C, A, B₁, B₆, B₉, E), minerals, dietary fiber and phytochemicals [1,2]. Some phytochemicals of vegetables are strong antioxidants and are thought to reduce the risk of chronic disease by protecting against free radical damage, by modifying metabolic activation and detoxification of carcinogens, or even influencing processes that alter the course of tumor cells [1, 3, 4]. 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, anemia, gastric ulcer, rheumatoid arthritis, and other chronic diseases [5, 6]. A high vegetable diet has been associated with lower risk of cardiovascular disease in humans [7]. Low vegetable intake, in unbalanced diets, has been estimated to cause about 31% of ischemic 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 [8]. 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 phytonutriceuticals in vegetables are responsible for mitigating some of these diseases.

A world vegetable survey showed that 402 vegetable crops are cultivated worldwide, representing 69 families and 230 genera [9, 10]. Leafy vegetables of which the leaves or young leafy shoots are consumed were the most often utilized (53% of the total), followed by vegetable fruits (15%), and vegetables with below ground edible organs comprised 17%. Many vegetable crops have more than one part used. Most of the vegetables are marketed fresh with only a small proportion processed because most vegetables are perishable. Consumption shortly after harvest guarantees optimal vegetable quality. Nutrition is both a quantity and a quality issue, and vegetables 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.

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. Consumer's interest in whole foods with enhanced nutritional qualities is at an all-time high, and more consumers are choosing foods on the basis of their health benefits. This article makes a review

and discusses the nutritional quality and health benefits of the major groups of vegetables.

2. NUTRITIONAL QUALITY AND HEALTH BENEFITS OF VEGETABLES:

There is a general belief among nutritionists and health professionals that the health benefit of vegetables should not be linked to only one compound or one type of vegetable, but rather a balanced diet that includes more than one type of vegetable is likely to provide better protection. All the vegetables may offer protection to humans against chronic diseases. With the exception of glucosinolates and thiosulfides, which are unique to the crucifers and alliums, the phytonutrient content of a number of other vegetables consist primarily of vitamin C, fiber, selenium, folate and polyphenolics (carotenoids and flavonoids). The main difference is that each vegetable group contains a unique combination and amount of these phytonutrients, which distinguishes them from other groups and vegetables within their own group. For example the Apiaceae family (e.g. celery, parsley, carrot) is rich in flavonoids, carotenoids, vitamin C, and vitamin E. Celery and parsley for example are among the best vegetables sources for the flavonoid apigenin and vitamin E [11], and carrots have a unique combination of three flavonoids: kaempferol, quercetin, and luteolin [12]. In carrot, overall carotenoid levels have increased dramatically in the past four decades through traditional breeding to reach levels of 1000 ppm carotenoids, on a fresh weight basis [13]. The Asteraceae or Compositae family (e.g. lettuce, chicory) is rich in conjugated quercetin, flavonoids, and tocopherols. Crozier *et al.* [14] observed sizeable variations in flavonol content were also observed with lettuce cultivars by these authors [22]. The commonly consumed small "round" lettuce contained only 11 µg/g fresh weight of quercetin, and the levels in "iceberg" lettuce were even lower. In contrast, the outer leaves of "Lollo Rosso", a red cultivar of lettuce, contained 911 µg/g. The red color of this lettuce is due to high levels of anthocyanins, which like quercetin are products of the phenylpropanoid pathway. As one end product of the pathway has been elevated, it may well be that other related compounds, including the flavonols, are also found in higher concentrations. Roman lettuce is richer in lutein than head lettuces; and leafy and roman lettuces are richer in quercetin [15]. The Cucurbitaceae family (e.g. pumpkin, squash, melon, cucumber) is rich in vitamin C, carotenoids, and tocopherols [16]. Burger *et al.* [17] in a survey of 350 melon accessions from different horticultural groups of *Cucurbita melo* observed a 50 fold variation in ascorbic acid content, ranging from 0.7 mg to 35.3 mg/100g of fresh fruit weight. Ascorbic acid and β-carotene content ranged from 7.0 to 32.0 mg/100g and 4.7 to 62.2 µg/100g, respectively in sweet melons [18]. Bitter gourd (*Momordica charantia*) has anti diabetic properties and can be used to ameliorate the effects of type-2 diabetes. Diet is the primary therapy for this type of diabetes and bitter gourd is particularly critical when pharmaceuticals

are not available, as happens in a great part of the developing world [2]. The Chenopodiaceae family (e.g. spinach, Swiss chard, beet greens) is an excellent source of folate [19] and has been shown to inhibit DNA synthesis in proliferating human gastric adenocarcinoma cells [20]. The Chenopodiaceae vegetables are also among the most oxalate dense vegetables [21]. When oxalates become too concentrated in body fluids, they can crystallize and cause health problems such as kidney calcium oxalate stones. All the legumes (Fabaceae or Leguminosae family; e.g. bean, pea, soybean, chickpea, lentils), mature and immature seeds are good sources of dietary fiber and isoflavonoids [22]. Mallillin *et al.* [23] determined the total, soluble and insoluble fibre and fermentability characteristics of ten legumes mature seeds (mungbean, soybean peanut, pole sitao, cowpea, chickpea, green pea, lima bean, kidney bean and pigeon pea) and concluded that the dietary fibre content ranged from 20.9 to 46.9 g/100g and that the best sources after *in vitro* fermentation using human faecal inoculum stimulating conditions in the human collon (as mmol/g/fibre isolate of acetate, propionate, butyrate produced after fibre fermentation measured by HPLC) were pole sitao and mungbean (acetate), kidney bean and pigeon pea, (propionate), and peanut and cowpea (butyrate). High flavonol legumes include sugar snap peas and mange tout, which were found to contain 98 and 145 µg quercetin/g respectively. Some legumes are also rich in iron. Trinidad *et al.* [24] determined the mineral availability *in vitro* of iron, zinc and calcium in ten local legumes (cowpeas, mung beans, pole sitao, chickpeas, green peas, groundnuts, pigeon peas, kidney beans, lima beans and soybeans). They found that the highest iron availability among legumes was for lima beans (9.5 (sem 0.1)) and mung bean while for zinc and calcium, the highest availability was for kidney beans (49.3 (sem 4.5)) and pigeon peas (75.1 (sem 7.1)), respectively. Ground nuts have the lowest Fe (1.3 (sem 1.1)), Zn (7.9 (sem 1.3)) and Ca (14.6 (sem 2.8)) availability. They concluded that mineral availability of Fe, Zn, and Ca from legumes differs and may be attributed to their mineral content, mineral-mineral interaction and from their phytic and tannic acid content. For example mungbean (*Vigna radiata*) either eaten as whole pod grains or grown to produce bean sprouts, is an important source of iron for women and children throughout South Asia [8].

3. CONCLUSION

Regular consumption of a vegetable rich diet has undeniable positive effects on health since phytonutrients 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. Various components of the whole food are likely to contribute to the overall health benefit. Various phytonutrients with antioxidant properties may work directly by quenching free radicals or indirectly by participating in cell signaling pathways sensitive to redox balance. Nutrients such as

potassium contribute to blood pressure regulation. The dietary fiber content and type of different vegetables may also contribute to the overall health benefit, such as improving bowel transit, lowering cholesterol, helping manage blood glucose concentrations, and by transporting a significant amount of minerals and phytochemicals linked to the fiber matrix through the human gut. Finally, increasing vegetables in the diet may reduce the intake of saturated fats, trans fats, and foods with higher caloric density, all of which may be related to a healthier overall diet. Because each vegetable contains a unique combination of phytonutrients (vitamins, minerals, dietary fiber and phytochemicals), a great diversity of vegetables should be eaten to ensure that individual's diet includes a combination of phytonutrients and to get all the health benefits. The availability of a large diversity of vegetables year-round, allied to increase in mean per capita incomes in recent years and knowledge of vegetable health benefits, have enabled consumers to include a variety of health promoting phytonutrients in their diet.

Nutritional quality as understood by the consumers and available at a moderate price may encourage enhanced consumption, thereby conferring an important marketing incentive to plant breeding. Research on the health benefits of vegetables, from a horticultural and breeding perspective, needs to focus on key areas in the near future such as:

- 1) To continue the evaluation of phytonutrient content among older versus newer major cultivars
- 2) To identify the genetic mechanisms that regulate the synthesis of their key phytochemicals, such as the glucosinolates, thiosulfides and flavonoids, in order to develop cultivars rich in a variety of phytochemicals and in order to ensure that a mixture of phytochemicals enters into the human diet
- 3) To study the potential change in the balance of these compounds (and their eventual synergisms or interactions) and
- 4) To identify the optimum conditions for maintaining these phytochemicals after harvest and processing since studies have shown that the bioavailability of some of the phytochemicals increase dramatically after storage and processing and others degrade rapidly.

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