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Role of vegetables in human nutrition and disease prevention

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Abstract
Vegetables are important for human health because of their vitamins, minerals, phytochemical compounds, and dietary fiber content. Especially antioxidant vitamins (vitamin A, vitamin C, and vitamin E) and dietary fiber content have important roles in human health. Adequate vegetable consumption can be protective some chronic diseases such as diabetes, cancer, obesity, metabolic syndrome, cardiovascular diseases, as well as improve risk factors related with these diseases. In this chapter, basic information will be given about the classification of vegetables, preparation and cooking, and their effects on food content of vegetables and effects on health and diseases (diabetes, obesity, metabolic syndrome, cardiovascular diseases, and cancer).

Keywords: Vegetable, Nutrition, Human and diseases

1. Introduction
Vegetables are annual or perennial horticultural crops, with certain sections (roots, stalks, flowers, fruits, leaves, etc.) that can be consumed wholly or partially, cooked or raw. Vegetables are important for human nutrition in terms of bioactive nutrient molecules such as dietary fiber, vitamins and minerals, and non-nutritive phytochemicals (phenolic compounds, flavonoids, bioactive peptides, etc.). These nutrient and non-nutrient molecules reduce the risk of chronic diseases such as cardiovascular diseases, diabetes, certain cancers, and obesity. In recent years, consumers began to change their eating patterns with the growing interest in the effect of foods in staying healthy and maintaining health. "Western" type diets are characterized by increased intake of calories, sugar, saturated fats and animal protein, and reduced consumption of vegetables and fruits. When this type of diet is combined with lack of activity, the prevalence and frequency of diseases such as obesity, diabetes, and cardiovascular pathologies also increase. In healthy diets (Mediterranean diet model), eating plant-based foods such as fruits and vegetables, cereals, legumes and nuts, replacing butter with healthy oils such as olive oil and canola oil, using herbs and spices to add flavor instead of salt, limiting red meat to several times a month and eating fish and poultry at least twice a week are recommended. Evidence from epidemiological studies and clinical trials shows that the Mediterranean diet is associated with many positive health outcomes such as reduced risk of various chronic illnesses, reduced overall mortality, and increased likelihood of healthy aging. One of the most important features of these diets is the high consumption of vegetables, and therefore fiber, vitamins, minerals, flavonoids, phytoestrogens, sulfur compounds, phenolic compounds such as monoterpenes and bioactive peptides, which have positive effects on health. In this chapter, basic information will be presented on the classification of vegetables, their relation to health, and the effects of preparation and cooking on nutrient content of vegetables.

2. Classification of vegetables
There are approximately 10,000 plant species used as vegetables in the world. Classification of these species can be done by considering a common set of features. It is important for food researchers, dietitians, and nutrition educators to subcategorize vegetables by taking into account health and nutrition. This sub-categorization will be more useful if it is based on similarities in food composition. Vegetables can be classified according to the part of the plant used for nutrition and the specific nutritional value.

2.1. Green vegetables

2.1.1. Leaf vegetables

This group includes spinach, lettuce, curly lettuce, chard, purslane, chicory, etc. These are important minerals (iron and calcium), vitamins (A, C, and riboflavin) and fiber sources. Young, fresh leaves contain more vitamin C than mature plants. The green outer leaves of lettuce and cabbage are richer in vitamins, calcium, and iron than white inner leaves. Thinner and greener leaves are more nutritious and usually have lower calories.

2.1.2. Stalk vegetables

The best examples to be given to stalk vegetables are celery and asparagus. They contain minerals and vitamins in proportion to the green color. Asparagus is a particularly rich source of folic acid.

2.1.3. Fruit and flower vegetables

Broccoli, cauliflower, and artichoke are frequently consumed flowering vegetables. Broccoli is a good source of iron, phosphorus, vitamins A and C, and riboflavin. Cauliflower is also a good source of vitamin C. The nutritional value of the outer leaves of cauliflower and broccoli is much higher than the flower buds. They can be consumed raw in salads or cooked. Artichoke is a good source of minerals, especially potassium, calcium, and phosphorus, and has high dietary fiber content. Tomatoes and peppers are the most common fruit vegetables. Both are rich in vitamin C. Other fruit vegetables include cucumber, zucchini, and eggplant. A dark green or yellow color indicates high β-carotene content. The darker the yellow color, the higher the content of β-carotene.

2.2. Root vegetables

2.2.1. Root, bulb, and tuber vegetables

Carrot, beet, turnip, fennel, onion, radish, and potato are examples of this group of vegetables. Yellow and orange varieties are rich in β-carotene, which is the precursor of vitamin A. Onion is an extraordinary example of root vegetables and contains moderate levels of vitamin C.

2.2.2. Legumes

This group includes legumes, peas, and soya beans. This group is rich in saponin and soluble fiber. Subgroups may differ from country to country and classifications in nutritional guidelines are based on nutritional content in different countries. For example, the basic food guidelines used in the United States (Basic 7 and Basic 4 Food Groups and Food Guide Pyramid) are focused on dark green leafy and dark orange/yellow group vegetables for beta-carotene and citrus fruits for vitamin C. Later on, 2010 USDA MyPyramid food guide identified dark green leafy vegetables and broccoli, other leafy vegetables, legumes, unique vegetables (dark orange, tomato, allium vegetables, etc.) and additional vegetables [Table 1]. In the guide prepared by Turkish Ministry of Health (Turkey Nutrition Guide 2015), vegetables have been classified as Dark green leafy vegetables (Mediterranean/salad greens such as spinach, chard, quince, blackcurrant, vine leaf, curly, lettuce, spinach, purslane, parsley, cress, arugula, mint, sorrel, radish, dill, radica, and curly-chicory (chopped or in salads)), other green vegetables (broccoli, okra, fresh beans, fresh peas, green zucchini, artichokes, asparagus, brussels sprouts, varieties of pointed or stuffed peppers, cucumber, and iceberg lettuce (chopped or in salads)), Red-orange-blue-purple vegetables (tomatoes, carrots, red pepper, radish, winter squash, beet, aubergine, and red cabbage), white vegetables (onion, celery, cabbage, cauliflower, leek, mushroom, ground apple, turnip), and starchy vegetables (potatoes and fresh corn).

Table 1: The guide prepared by Turkish Ministry of Health

Vegetable subgroups	Important sources a	Contributes b
Dark green leafy vegetables and broccoli	Vitamin C Vitamin K Folate Beta-carotene Lutein + zeaxanthin, flavones	Iron, copper, manganese Vitamin B6 Phytosterol Alpha-carotene Flavonols TAC
Other leafy vegetables	Vitamin C Vitamin K Anthocyanidins	Phytosterol Manganese Vitamin B6 Folate Beta-carotene Lutein + zeaxanthin TAC
Legumes	Copper Folate Phytosterol Flavan-3-ols Flavonols TAC	Dietary fiber Magnesium, iron, zinc, manganese Vitamin B6
Unique vegetables	Vitamin C Alpha-carotene lycopene	Vitamin B6 Vitamin K Manganese, copper Beta-carotene
Additional vegetables	Flavonoids	Vitamin C Vitamin K

3. The effect of vegetables on some disease

3.1. Effects on diabetes, obesity, and metabolic syndrome

Diabetes mellitus (DM), obesity, and the metabolic syndrome (MS) are increasing health problems in recent years in parallel with the increase in unhealthy eating habits and unhealthy living behaviors. One of the most basic aspects of the control and management of the disease in individuals with these health problems is the regulation of eating habits. In medical nutrition therapy applied to these individuals, it is important to meet the energy and nutritional needs of individuals, as well as including foods with functional activities against the complications of these diseases in the diet. Phytochemical compounds (carotenoids, alkaloids, terpenoids, and phenolics), which are secondary compounds found in vegetables, are thought to be protective against these diseases.

3.1.1. Root, bulb, and tuber vegetables

Onions and garlic, thanks to the volatile oils, organosulfur compounds, and flavonoids in their content, are among the vegetables thought to be protective against DM, obesity, and MS. Organosulfur compounds such as S-methyl cysteine and flavonoids such as quercetin in these vegetables exert a functional effect by regulating the activities of some enzymes involved in carbohydrate metabolism, increasing insulin secretion and sensitivity, and increasing NADP+ and NADPH activities. In addition, these vegetables inhibit the enzymes α-glucosidase and α-amylase, inhibiting the formation of D-glucose from oligosaccharides and disaccharides and delaying

the absorption of glucose from the intestines. Onion and garlic are especially protective against dyslipidemia and oxidative stress, which are seen due to DM and MS.

Kumar *et al*. found that obese patients with Type 2 diabetes who used garlic tablets in addition to metformin had significantly higher fasting blood glucose (FBG), postprandial blood glucose, total cholesterol (TC), triglyceride (TG), low density lipoprotein cholesterol (LDL), C-reactive protein (CRP), and adenosine deaminase levels compared to those of patients using only metformin. In dyslipidemic individuals with Type 2 DM, the use of garlic tablets for 12 weeks significantly decreased TC and LDL levels, while high-density lipoprotein cholesterol (HDL) levels were significantly increased. Although there are similar studies suggesting that garlic has positive effects on blood glucose level and plasma lipid profile in the presence of DM, garlic was also found to increase antioxidant enzyme activities in DM and reduce bioactive aldehyde levels.

3.1.2. Fruit and flower vegetables

Broccoli and cauliflower are vegetables thought to have protective effects against many diseases thanks to glucosinolates and indole-3-carbinol they contain. Indole-3-carbinol given to obesity induced mice by a high fat diet was shown to reduce epididymal fat accumulation, body weight, insulin, leptin, and blood glucose levels, increase adiponectin levels, and improve glucose tolerance. Similarly, in Type 2 diabetic rats fed with a high fat diet, indole-3-carbinol reduced blood glucose levels, and HbA1c levels, thereby reducing thiobarbituric acid reactive substances, lipid hydroperoxides and conjugated dienes levels, and increased levels of SOD, CAT, and GSH-Px. Positive effects of broccoli on impaired lipid profile due to high fat diets were detected.

3.2. Effects on cancer

Cancer occurs as cells grow and proliferative without control Cancer occurs, progresses, and spreads as a result of abnormal signals in the body due to genetic or epigenetic effects. Cancer is among the main causes of death in the world. On average, 16% of deaths occur each year due to cancer. Lifestyle and many genetic and environmental factors can cause cancer. Smoking, consumed foods, solar radiation, and carcinogens in the environment are among these factors. The most important step in the treatment of cancer is the prevention of cancer. In particular, it is important to use health-related preventive practices in the communities and individuals at risk. Consuming plant-based foods, especially increasing the consumption of vegetables, reduces the risk of cancer. The antioxidants in vegetables help reduce the risk of cancer by preventing oxidative damage to the cells in the body. Vegetables have protective effects against cancer due to the vitamins, minerals, pulp, and phytochemicals they contain. About 14% of deaths worldwide due to inadequate vegetable consumption are caused by gastrointestinal cancers.

In a meta-analysis, the effects of vegetable consumption on cancer incidence were examined. Fruit and vegetable consumption were found to decrease cancer risk independently of each other and it was found that an extra portion of vegetables consumed daily resulted in a 3% reduction in cancer incidence.

A study investigating the relationship between vegetable and fruit consumption and epithelial ovarian cancer included 500 cancer patients and 500 control subjects. Cancer patients were found to have significantly lower average amounts of vegetables and fruits consumed per day than the control group. However, in a cohort study investigating the relationship between vegetable and fruit consumption and pancreatic cancer, no significant relationship was found.

4. Effect of preparing and cooking methods on vegetables

Vegetables are one of the most important components of human diet and are rich sources of β-carotene (provitamin A), thiamine (B1), riboflavin (B2), niacin (B3), pantothenic acid (B5), pyridoxine (B6), folic acid, ascorbic acid (vitamin C), vitamins E and K, minerals (such as iron, zinc, calcium, magnesium, and selenium), antioxidants (such as carotenoids, polyphenols, and glucosinolates), and fiber. Preparation and cooking methods can greatly affect the nutritional content and acceptability of vegetables. There is no consensus in the literature as to what is the best way of preserving bioactive compounds while preparing and cooking vegetables. Some vegetables are subjected to peeling in order to remove their shell or skin and make them more digestible. Minerals and other nutrients are affected by peeling. This can also cause severe loss of certain vitamins. It is known that peeling before boiling increases the loss of ascorbic acid, folic acid, or other vitamins of group B. Chopping vegetables can also change the bioavailability of bioactive compounds such as vitamins, carotenoids, polyphenols, and flavonoids. Thawing, cutting, and crashing citrus vegetables can also disrupt antioxidant glucosinolates due to the presence of myrosinase enzyme found in these vegetables.

Cooking improves the flavor of vegetables and enables the nutrients in the vegetables to be more easily used by the digestive system. However, cooking results in some physical and chemical changes in vegetables. The effect of cooking procedure may vary depending on the various factors such as cooking technique, temperature, leakage into the cooking environment, solvent used for extraction, surface area exposed to water and oxygen, and pH. In addition, each food matrix contains different compounds; therefore the same cooking technique may have different effects depending on the type of vegetable.

5. Conclusion

Numerous preclinical studies carried out in recent years have identified beneficial protective and enhancing effects of vegetables on health, resulting from the nutritional and non-nutritional phytochemical contents of vegetables. These phytochemicals have the ability to modify the cellular function by modulating transcription factors and altering gene expression, cellular metabolism, and cellular signaling. The World Health Organization (WHO) recommends daily intake of 5–8 portions (400–600 g) of fruits and vegetables to reduce the risk of micro nutrient deficiency, cardiovascular diseases, cancer, cognitive impairment, and other nutritional health risks.

In order to make optimum use of the nutritional content of vegetables, choosing the right methods of preparation and cooking is as important as the consumption of adequate amounts of vegetables. To minimize nutritional losses, vegetables should be chopped right before cooking, if possible by hand or by metal tools while making the minimum contact possible, each vegetable should be cooked with the method and time that is most appropriate for that vegetable, and consumed as soon as possible.

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