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Red cabbage, millennium's functional food

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Abstract Red cabbage (RC), known also as purple cabbage is very low in saturated fat, cholesterol and a source of thiamin, riboflavin, folate, K, Ca, Fe, Mg and Mn, dietary fiber, vitamins A, C, K, B, providing big amounts of anthocyanins and presenting high antioxidant properties which may decrease the risk of cardiovascular diseases, brain disorders and cancer.

Key words

mineral content, vitamins, glucosinolates, cancer prevention

A functional food is "a food given an additional function (often one related to health-promotion or disease prevention) by adding new ingredients or more of existing ingredients" [16].

Cabbage was cultivated from wild cabbage that is native to coastal regions of the Mediterranean. The ability of cabbage to withstand cold climates allowed it to spread across northern Europe and become an important staple in european cuisine. It has long been valued for its many medicinal properties and its ability to effortlessly morph into winter comfort food or a light summery slaw [13].

Red cabbage (*Brassica oleracea* L. *var. capitata f. rubra*) is native to southern Europe. At present, it is grown all over Europe [13]. This variety is plentiful year round, but tastes the best when grown in cooler climates. It is a fall/winter vegetable that has crunchy; mildly peppery-sweet leaves [13]. Containing "a litany of vitamins, minerals and phyto-chemicals, cabbage is one of those veggie super foods, presenting more vitamin C than an orange (per serving), providing 61% of the daily vitamin K needs, and including healthy amounts of vitamin B5 (panthothenic acid), vitamin B6 (pyridoxine), and vitamin B1 (thiamin), red cabbage is a fantastic source of antioxidants and phyto-chemicals and contains a plethora of minerals", including potassium, manganese, iron, and magnesium [8].

Red cabbage (RC), is more unique among the cruciferous vegetables in providing a big quantity of anthocyanins, which qualify not only as antioxidant nutrients, but also as anti-inflammatory nutrients. The antioxidant richness of cabbage is partly responsible for its cancer prevention benefits [21]. RC is used mostly as an ingredient in raw vegetable salads which contain a full range of vitamins, minerals and substances which have a beneficial impact on human health. RC is popular for the natural colorant used for different products [20].

Raw RC contains 6 - 7 g of total carbohydrates for one 85 g serving, which is similar to almost 67 % of RC's caloric content per serving. The carbohydrate compounds in RC are provided by dietary fiber and natural sugars. Mayo Clinic recommends eating high-fiber foods like RC because a diet rich in dietary fiber may help prevent colon cancer, high cholesterol, diabetes and obesity and provides 20 % of the RDA of vitamin A. RC is appreciated to contain one of the highest concentrations of antioxidants of all vegetables [14]. According to many studies cabbage presents a number of anti-cancer compounds, like lupeol, sinigrin, and sulforaphane, which are known to stimulate enzyme activity and inhibit the growth of tumors, which can lead to cancer [15].

Materials and Methods

For the development of the present paper, we analyzed over 100 scientific papers and online resources in the field of food chemistry, horticulture, agriculture and medicine in order to conduct a concise literature review of health and nutritional benefits of red cabbage.

Results and Discussions

More than 475 studies have examined the role of cabbage in cancer prevention (and in some cases, cancer treatment). The uniqueness of cabbage in cancer prevention is due to the three different types of nutrient richness: antioxidant richness, anti-inflammatory richness, and richness in glucosinolates [34].

While green cabbage is the most commonly eaten variety of cabbage, red cabbage presents added nutritional benefits and it's recommended also by its robust hearty flavor. The rich red color of red cabbage reflects the concentration of anthocyanin polyphenols,

which "contribute to red cabbage containing green cabbage" [34]. significantly more protective phyto-nutrients than

Table 1

Nutrients in Cabbage (100 grams)

Nutrients	Abundance	Reference
WHITE CABBAGE		
Polyphenols	45 milligrams of polyphenols including 0.01 milligram of anthocyanins; 5.72 mg/g extract; 11.1 mg/g; 0.36 - 0.4 mg total phenolics/g F.W.; 1.10-1.53 mg total phenolics/g F.W.;	[34] [5] [22] [4, 9] [24]
Total antioxidant capacity	0.025 mmol Trolox/g;	[5]
Vitamin C	32.6 - 36.6 mg/ 100g F.W., Daily Value 60-61%;	[3, 12, 32, 34, 36]
Calories	21;	[15, 17, 18]
Calories from Fat	0.11g/100 g F.W.;	[35]
Vitamin A	98 IU/100 g F.W.;	[35]
Calcium	40 mg/100g F.W.;	[35]
Magnesium, Mg	12 mg/ 100g F.W.;	[35]
Iron, Fe	0.47 mg /100g F.W.; 56.16±10.35 $mgkg^{-1}$ D.W.;	[35] [2]
Copper, Cu	6.03±0.27 $mgkg^{-1}$ D.W.;	[2]
Zinc, Zn	0.18 mg/ 100g; 78.93±26.37 $mgkg^{-1}$ D.W.;	[35] [2]
Manganese, Mn	24.3±6.27 $mgkg^{-1}$ D.W.;	[2]
Carbs	4.97g; 5.8 g/100 g F.W.;	[35]
Protein	1.28g;	[35]
RED CABBAGE		
Polyphenols	100 g a raw red cabbage provides 196.5 mg of polyphenols 28.3 mg of which are anthocyanins; 254.00 mg/100 g F.W.; Total phenolics 139.3mg GAE /100g F.W.; 322 mg/100 g;	[34] [37] [27] [23]
Vitamin C	57 mg; 45.8 mg; 37 mg;	[11, 15] [30] [29]
Calcium, Ca	44.5 mg; 0.56 g/100 g D.W.	[28] [26]
Magnesium, Mg	14 mg; 0.13 g/100 g D.W.;	[25] [26]
Iron, Fe	0.45 mg; 53.17 g/100 g D.W.;	[33] [26]
Copper, Cu	0.031 mg; 4.92 g/100 g D.W.; 9.42±0.53 $mgkg^{-1}$ D.W.;	[1] [26] [2]
Zinc, Zn	0.19 mg; 114.00±18.08 $mgkg^{-1}$ D.W.;	[1] [2]
Manganese, Mn	0.20 mg; 23.1±5.4 $mgkg^{-1}$ D.W.;	[25] [2]
Nickel, Ni	10 µg; 0,01 mg;	[25]

The anthocyanin pigments are recommended mostly due to their health benefits as dietary antioxidants, as an anti-inflammatory, and their potentially protective, preventative, and therapeutic roles in many of the human diseases [34].
The most important nutrients present in white and red cabbage are presented in table 1.
Epidemiological studies states that certain cruciferous vegetables consumption reduces various types of cancer due to its enriched content of Glucosinolates (GLS) [31]. There have been identified over 120 different glucosinolates, which can be classified, according to their structure as aliphatic, aromatic, ω-methylthioalkyl and heterocyclic (e.g., in-dole) glucosinolates [6, 7]. By food preparation glucosinolates, are transformed into isothiocyanates (ITCs), which alter the metabolism of carcinogens. Indoles and ITCs, two major glucosinolate breakdown products, attenuate the effects of polycyclic aromatic hydrocarbons and nitrosamines via induction of GSTs and inhibition of cytochrome P450 isoenzymes, respectively [36]. Human intervention studies with cruciferous vegetables have demonstrated induction of GSTs by consumption of Brussels sprouts and red cabbage varieties, but not with white cabbage and broccoli. The particular isoform of the enzyme induced may protect against bladder cancer. Consumption of red cabbage also has an effect on drug metabolism in humans, and leads to specific changes in the patterns of meat-derived urinary mutagens. ITCs may also protect against mutations formed by tobacco carcinogens [36].
Given the roles of oxidative stress and chronic inflammation as risk factors for cancer, the antioxidant and anti-inflammatory richness of cabbage would provide anti-cancer health benefits even without the addition of cabbage's glucosinolates. But glucosinolates are cabbage's trump card with regard to "anti-cancer" benefits because the glucosinolates found in cabbage can be converted into isothiocyanate compounds that are cancer preventive for a variety of different cancers, including bladder cancer, breast cancer, colon cancer, and prostate cancer [34]. RC not only contains isothiocyanates but also contains anthocyanins, a class of flavonids that provides as many as 36 different varieties of anticancer chemicals [10]. Also contains a significant amount of glutamine, an amino acid that has anti-inflammatory properties. RC boosts the immune system's ability to produce more antibodies. At the same time RC contains large quantities of sulfur and other minerals that work as cleansing agents for the digestive system. Raw red cabbage cleans the bowels, thus helping to prevent indigestion and constipation [10]**.** Raw Cabbage juice has been used historically to repair the stomach lining and heal ulcers [10].

Conclusions

Red cabbage belonging to *Brassicaceae* family is a vegetable with high total antioxidant capacity being also very rich in minerals, vitamins, polyphenols, anthocyanins and glucosinolates. Red cabbage is just like green cabbage in taste and texture, but with the added benefit of anthocyanins which give the distinctive color. The anthocyanins have a wide range of therapeutic advantages without adverse effects; including cardiovascular protective properties. Glucosinolates are digested into isothiocyanates that reduce inflammation and fight bacteria. At the same time the glucosinolates present in red cabbage reduce various types of cancer due to its enriched content. Increasing the access to knowledge about red cabbage consumption could be essential for individuals to find a cheap way to improve life and health.

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