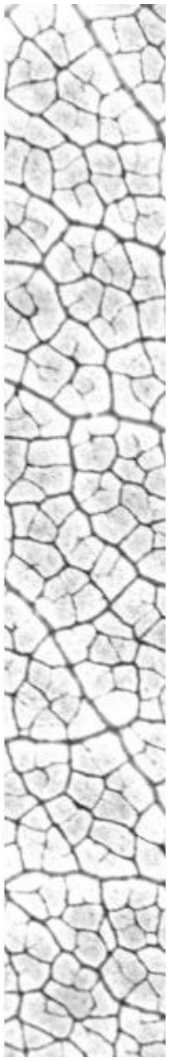

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Nutritional value and antioxidant activity of brassica oleracea and coriandrum sativum vegetable crops

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Abstract
The search and study of promising natural sources of compounds with antioxidant activity is an urgent task. In this work the food value and antioxidant properties and phenolic and flavonoid compounds of Brassica oleracea (white cabbage) and Coriandrum sativum (cilantro) are investigated. DPPH, ABTS and β-Karoten/linoleic acids have been used to determine the antioxidant activity. By mineral composition cilantro is rich in sodium (5490.05 mg/kg), iron (43.59 mg/kg), magnesium (440.31 mg/kg), while cabbage has high calcium content (1515.09 mg/kg), potassium (4003.32 mg/kg), phosphorus (737.87 mg/kg). In terms of vitamin composition, white cabbage is a rich source of vitamin C (432.64 mg/kg), whereas vitamin A (2.46 mg/kg) and vitamin E (1.85 mg/kg) prevail in cilantro. The antioxidant activity varied according to the model system used, all extracts generally exhibited strong antioxidant activity. B. oleracea and C. sativum extracts contain significant amounts of phenols and flavonoids.

Keywords: radical scavenging activity, phenol, flavonoid, mineral composition, extract

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INTRODUCTION

Foods are an important factor in the formation of human health and the gene pool. However, most of today's food products of mass consumption have low biological value. This is due to the poor ecological condition of the environment, the use of film coatings, mineral fertilizers and chemical agents for pest and weed control in agriculture; the use of traditional food production technologies that include the refining of raw materials; the use of synthetic food additives (Kakimov et al. 2017, Okuskhanova et al. 2019). The research into ways of fortifying food with vitamins - antioxidants, essential amino acids, dietary fibres, macro- and micronutrients and other essential components - is a goal set by leading food producers in all countries (Kassenov et al. 2019, Zinina et al. 2019).

Studies conducted in this direction show the promising use of vegetable crops such as: white cabbage B. oleracea and cilantro (Coriandrum sativum), as an additive in the development of high biological value milk products as a source of vitamins, minerals, dietary fiber, including pectin and others (Ksenz and Lobanov 2008, Loaiza and Cantwell 1997).

Among the vegetable crops the cabbage occupies one of the leading places by cultivated area, by crop yields, as well as by consumption for food. This is due to its ability to keep fresh during winter and spring, its suitability for processing, souring and canning. The large variety of cabbage varieties with different speed of maturity allows for fresh produce throughout the year. This crop is also widely spread due to its nutritional value.

White cabbage (Brassica oleracea) is one of the highest yielding vegetable crops. Wide distribution of white cabbage is caused not only by high yield, but also by high transportability, resistance to unfavorable environment, high nutritious, taste and dietary properties. All types of cabbage are used for consumption all year round in fresh or processed form: for cooking, frying, stewing, preparing salads, souring, marinating, drying, canning, etc. Cabbage is also used for feeding animals, especially its waste. Cabbage is a rich source of carbohydrates, proteins, mineral salts (calcium, potassium, phosphorus, iron, etc.), vitamins C, P, PP, K, group B, carotene, organic acids and other valuable substances. Types of cabbage differ slightly in chemical composition. Cabbage carbohydrates are represented mainly by sugars. There are also starch,

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fibre, hemicellulose and pectin substances (Borisov et al. 2011).

In white cabbage the main sugars are glucose and fructose. In terms of glucose content (2.6%) white cabbage is slightly superior not only to the most common vegetable crops, but also apples, oranges and lemons. Its fructose saturation is better than potatoes (1.6 times), as well as beets, onions, lemons. The nutritional value of cabbage proteins is determined by their digestibility and the quantitative and qualitative composition of amino acids. The amino acid composition of white cabbage proteins is complete in nutritional terms. Its lysine content is 1.5 times higher than that of carrots and tomatoes, behind only potatoes and beets. Limiting amino acids for white cabbage are phenylalanine, tyrosine and leucine, while for other foods they are mainly lysine. Consequently, by consuming this vegetable, the human body satisfies in significant amounts its needs for essential amino acids that cannot be synthesized in the human body (Adeoye et al. 2019, Ludilov et al. 2011).

The biological value of cabbage is determined not only by vitamins and minerals. The organic acids comprise a significant proportion (12-15%) of the cabbage dry matter. Cabbage contains malic, citric, amber, fumaric and oxalic acids. Organic acids are actively involved in alkalizing the internal medium of the body, in neutralizing acidic products that are formed in metabolic processes. Organic acids have a beneficial effect on digestion, increasing the secretion of digestive glands and intestinal motility (Tipsina and Tashlykova 2010).

Vegetable fibers of cabbage, irritating the mechanoreceptors embedded in the walls of the gastrointestinal tract, enhance its motor and secretory function of the digestive glands. In addition, the cabbage cell membranes contribute to the removal of cholesterol from the body. Scientific and traditional medicine recommends using fresh cabbage and its juice to prevent diabetes, atherosclerosis, coronary heart disease, gallstone and ulcer (Livlandsky et al. 1999).

Cilantro (Coriandrum sativum) is an annual herbaceous plant with an excellent odour. It is often used to give a culinary flavour. It is also called coriander (from the Latin Coriándrumsativum). Cilantro contains a huge amount of useful substances and valuable essential oils. The ripe fruits of the plant are valued for their unique characteristics. The seeds contain from 0.7% to 1% essential oils including linanol (up to 70%) and geranium (up to 5%) (Wong and Kitts 2006). The uniqueness of cilantro is represented in its composition, rich in amino acids, vitamins and minerals, in addition, the essential oil contains: decylic aldehyde, decylic acid, felandren, terpinolene, borneol, fatty acid glycerides, tannins, vitamins A and B, organic acids, fructose, sucrose, glucose. Among minerals, cilantro contains most potassium, calcium, magnesium and sodium. Copper, zinc, manganese and selenium are less abundant in spices. The beneficial effects of even small amounts of cilantro are due to the vitamins.These are B, PP, C, K vitamins. In 100 g of green leaves most carbohydrates - 3.67 g, followed by proteins - 2.13 g, but almost no fat - 0.52 g (Tatarinov).

Fig. 1. Stages of obtaining plant extracts

Due to the health hazards of synthetic antioxidants, natural food additives with high antioxidant activity have been studied in recent years. With the expansion of the global market and strong rivalry between multinational companies, the antioxidant activity parameter will soon find its place in food labelling. In this sense, the development and use of a practical method for determining the antioxidant activity for industrial use will become compulsory. This will result in a further increase in the use of fruits and vegetables (Sahib et al. 2013).

The aim of the research work is to study the nutritional value and total antioxidant content of vegetable crops such as white cabbage (Brassica oleracea) and cilantro (Coriandrum sativum).

MATERIALS AND METHODS

All studies were conducted at the Secondary Metabolites Laboratory of Pamukkale University, Turkey. B. oleracea and the surface organs of C. sativum, i.e. leaves and stems, were dried. Ten grams of each sample was added to an Erlenmeyer flask and then 100 ml of solvents with different polarity (ethanol, acetone and water) were poured to the samples. The extraction was done by shaking at 50 C for 6 hours in a thermostatically controlled shaker. Then the extract was separated from the sample residue by filtering through a filter paper Whatman No. 1. Filtering was made twice and the resulting solution was evaporated at 40 ° C to 50 ° C using a rotary evaporator (IKA RV10D, Staufen, Germany). All extracts were lyophilized (Labconco FreeZone, Kansas City, MO, U.S.A.) and stored at (-20) °C before use.

Determination of Total Antioxidant Activity

β-carotene/linoleic acid method

The antioxidant activity of the plant extracts was determined according to the method of Amin and Tan. One milliliter of β-carotene solution (0.2 mg/mL chloroform) was put into a round-bottom flask containing 0.02 mL of linoleic acid and 0.2 mL of 100% Tween 20. The chloroform was evaporated using a rotary evaporator. Then, the mixture was diluted with 100 mL of distilled water. The reaction mixture and one milliliter extracts (1 mg/mL) were placed in test tubes. The initial absorbances were immediately measured with a spectrophotometer at 470 nm. The reaction mixture was incubated at 50 °C for 2 hours and the absorbance of this mixture was measured again (Amin and Tan 2002). The same process was repeated with BHT as a positive control. The total antioxidant activity (AA) was calculated as follows:

AA= [1- (Asamp-Aco)/(Aosamp-Aoco)] x 100

(Asamp and Aco: absorbance at the initial time of the incubation of samples and control, respectively and Aosamp and Aoco: absorbance in the samples and control at 120 min).

Measurement of Radical Scavenging Activity

Free radical scavenging activity (DPPH)

The DPPH free radical scavenging method is an antioxidant assay based on electron transfer. The DPPH method is a quick and simple way for calculating antioxidants by means of spectrophotometry. The scavenging activity of *A. acutifolius* extracts on DPPH radicals was measured according to the method of Meriga et al. Different concentrations (0.2-1.0 mg/mL) of the extracts (1 mL) were mixed with 4 mL of DPPH radical methanolic solution. The reaction mixture was kept in a dark room for 30 min. The absorbance measured at 517 nm. BHT was used as a control. Results were expressed as IC50 values. The values of IC50 denote the concentration of the sample that is required to scavenge 50% of DPPH free radicals (Ghorbaniparsa and Ofoghi 2016, Meriga et al. 2012).

ABTS radical cation scavenging activity

The ABTS method was conducted according to the procedure of Shalaby and Shanab with slight modifications. The ABTS cations were produced by reacting 7mM ABTS stock solution with 2.45 mM potassium persulfate. The reaction mixture was kept in a dark room for 12-16 h before use. The absorbance (0.700±0.05) of the diluted reacting mixture and ethanol (1:1) were measured at 734 nm for the study of the extracts. The ABTS solution was mixed with 0.1 mL of the extracts (1 mg/mL). The absorbance of the solutions were read at 734 nm after 15 min. The results were expressed as IC50 values. Ascorbic acid was used as the positive control (Shalaby and Shanab 2013).

Table 1. Content of macro and trace elements in cabbage and cilantro

Element	Daily rate, mg	Content in cilantro, mg/kg	Content in cabbage, mg/kg
Minerals			
Sodium	1300	5490.05	1012.70
Magnesium	400	440.31	243.84
Phosphorus	1200	475.28	737.87
Potassium	4700	1742.52	4003.32
Calcium	1000	667.72	1515.09
Trace elements			
Copper	1	4.37	1.51
Zinc	12	1.34	0.47
Selen	60	0.73	0.88
Iron	18	43.59	28.82
Chrome	5	0.043	0.027
Manganese	2	3.75	1.21
Aluminum	57	59.57	16.00

Total Phenolic Content

Total phenolic content was evaluated with the Folin-Ciocalteu method. The sample solution (1 mL) was mixed with 1 mL Folin-Ciocalteu reagent and 46 mL distilled water. After 3 min, 3 mL of 2% sodium carbonate (Na_2CO_3) solution was added. The mixture was allowed to stand for 2 h at room temperature and absorbance was measured at 760 nm. All the tests were performed in triplicate. Gallic acid was used for calibration and the results were expressed as mg of gallic acid equivalents (mg GAE g -1 extract) (Slinkard and Singleton 1977).

Total Flavonoid Content

Total flavonoid content of extracts was determined using the method of Arvouet-Grand. Briefly, 1mL of 2% $AlCl_3$ was mixed with the same volume of extract solution (2 mg/mL). The absorbance of the reaction mixtures were measured at 415 nm after 10 min incubation at room temperature. The flavonoid content was calculated from a quercetin standard curve (mg QEs/g extract) (Arvouet-Grand et al. 1994, Tipsina and Tashlykova 2010).

RESULTS AND DISCUSSION

Food Quality Index Study

The mineral composition of plant samples showed a significant content of macro- and microelements (**Table 1**). Thus, cilantro is rich in sodium (5490.05 mg/kg), iron (43.59 mg/kg), magnesium (440.31 mg/kg), calcium (667.72 mg/kg). Cabbage has high calcium content (1515.09 mg/kg), potassium (4003.32 mg/kg), phosphorus (737.87 mg/kg), iron (28.82 mg/kg).

The heavy metal content poses no danger to consumption (**Table 2**). The cabbage does not contain traces of cadmium, lead and cobalt. Contents of arsenic, zinc, nickel and chromium do not exceed MAC. The concentration of heavy metals in cilantro also does not exceed the established MAC.

Table 2. Content of heavy metals in white cabbage and cilantro

Heavy metal	Content in cabbage, mg/kg	Content in cilantro, mg/kg	MAC
Pb	Not detected	0.03	0.5
As	0.067	0.052	0.2
Cd	Not detected	0.01	0.03
Zn	0.47	1.34	10
Ni	0.37	0.38	0.5
Cr	0.027	0.043	0.2
Co	Not detected	Not detected	0.2

Table 3. Vitamin composition of cabbage and cilantro plants

Vitamin	Cabbage	Cilantro
Vitamin A	0.03	2.46
Vitamin C	432.64	25.75
Vitamin E	0.11	1.85

Table 4. Antioxidant properties of white cabbage extracts (Brassica olerasea)

Indicator	Acetone	Ethanol	Water	BHT	BHA
DPPH (%)	13.09	13.77	21.09	-	98.13
ABTS (%)	14.15	20.64	22.13	-	96.31
β- caroten/linoleic (%)	93.53	99.1	98.32	96.84	-

In terms of vitamin composition, white cabbage is a rich source of vitamin C, containing 432.64 mg/kg, while in cilantro - 25.75 mg/kg. Vitamin A (2.46 mg/kg) and vitamin E (1.85 mg/kg) prevail in cilantro compared to cabbage.

Antioxidant properties, phenolic and flavonoid compounds of B. oleracea and C. sativum

In the next stage, the antioxidant properties of B. oleracea and C. sativum, phenolic and flavonoid compounds were determined. DPPH, ABTS and β-Karoten/linoleic acids were used to determine antioxidant activity. DPPH is a permanent free radical. The lower the absorption of DPPH reaction mixture and antioxidant, the higher is the antioxidant free radical absorption activity (Adıgüzel et al. 2009).

In this work, the antioxidant activity of Brassica oleracea and Coriandrum sativum have not shown sufficiently high results compared to the standards of the VNT and BHA (**Table 4**). All extracts differ from each other and the results were expressed in percentages. The highest index in Brassica oleracea by DPPH method was found in an aqueous extract 21.09±0.21, while in acetone 13.09±0.13 and in ethanol 13.77±0.09 the results were not significantly different. High concentration of extracts in water 22,13±0,42 was also found by ABTS method in comparison with ethanol 20,64±0,53 and acetone 14,15±0,31. Extracts by β-Karoten/linoleik method showed very high antioxidant activity values. Compared to the standard, ethanol extracts of 99.1±1.61 showed high results. Water extracts 98.32±1.09 and acetone 93.53±1.52 showed significantly better results.

If to analyze the results of Coriandrum sativum, the maximum value for DPPH is found in acetone extract

Table 5. Antioxidant properties of Coriandrum sativum

Indicator	Acetone	Ethanol	Water	BHT	BHA
DPPH (%)	54.23	33.93	29.74	-	98.3
ABTS (%)	25.4	33.34	47.74	-	96.31
β- caroten/linoleic (%)	65.89	68.5	71.5	96.84	-

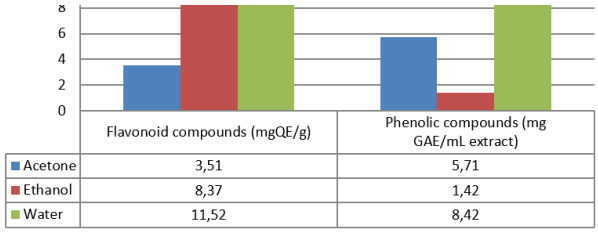

Fig. 2. Total phenols and flavonoids in white cabbage (Brassica olerasea)

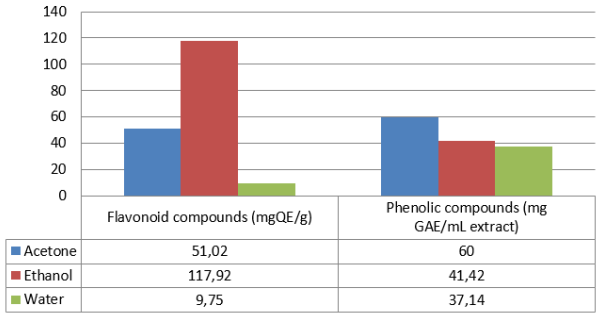

Fig. 3. Total phenols and flavonoids in cilantro (Coriandrum sativum)

54.23±0.43 (**Table 5**). Extracts of ethanol 33.93±0.32 and water 29.74±0.22 showed lower results. If we analyze the results of Coriandrum sativum using ABTS method, we noticed that in comparison with the standard (BHA) they have lower antioxidant properties, while in water extracts 47.74±0.21, in acetone extracts 25.40±0.63 and ethanol alcohol 33.34±0.51. The results of β-Karoten/linoleik antioxidant activity in Soriandrum sativum compared to the standard (BHT) have shown good results. The aqueous extract 71.5±1.02 showed better results than ethanol extract 68.5±1.06 and acetone extract 65.89±1.03.

In this study, the total flavonoid content in the extracts of B. oleracea and C. sativum was determined by the aluminum chloride spectrophotometric method. (**Figs. 2** and **3**). The total phenol content in the extracts was determined by the Folin-Ciocalteu method. The phenolic composition of Brassica oleracea differs from the solvents in the extracts. The highest index is observed in water 8.42±0.02 mgGAE/mL, ethyl alcohol 1.42±0.01 mgGAE/mL and acetone 5.71±0.01 mgGAE/mL. In Coriandrum sativum a high rate was found in acetone extracts of 60±0.52 mgGAE/mL. In ethyl alcohol extract 41.42±0.62 mgGAE/mL and in aqueous extract 37.14±0.31 mg GAE/mL phenol content was significantly reduced.

Flavonoid composition of Brassica oleracea depending on the solvents of extracts showed the

following results: in water 11.52±0.11 mgQE/g, in ethanol 8.37±0.06 mgQE/g and acetone 3.51±0.02 mgQE/g. The content of flavonoids in Coriandrum sativum depending on the solvent extracts: in acetone more than 51.02±0.52 mgQE/g, in ethanol more than 17.92±1.13 mgQE/g and in water more than 9.75±0.09 mgQE/g. Phenolic compounds (phenolic acid, flavonoid, etc.) are found in a large variety of plants and have many biological effects, including antioxidant activity. The determination of phenolic compounds in plants is very important in pharmacology and medicine. Flavonoids destroy harmful active oxygen species and are useful antioxidants. In addition, flavonoids are an important component of human nutrition (Mammadov 2014).

CONCLUSION

In this study, while values of antioxidant activity varied according to the model system used, all extracts generally exhibited strong antioxidant activity. B. oleracea and C. sativum extracts contain significant amounts of phenols and flavonoids. Extracts of B. oleracea, C. sativum contain antioxidant compounds. In addition, studies should be conducted to isolate and identify these components in the extracts. However, B. oleracea, C. sativum can be considered as an alternative source of antioxidant agents for pharmacological applications. The findings may provide additional information on the potential use of this plant as a dietary supplement. These studies may provide useful information for the prevention and treatment of various human diseases and for potential use in the human diet.

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