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Comparative assessment of mineral content and antioxidant properties of some cabage varieties available on Romanian market

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Abstract Cabbage is leafy vegetable that is currently used in human nutrition. In addition, it contains active compounds with antifungal, antibacterial, and anticancer activity. The present paper investigates the levels to which selected trace elements accumulate in various cabbage varieties available on Romanian market as well as the antioxidant properties of these vegetables. Our results revealed that purple cabbage varieties tend to accumulate higher amounts of Fe, Pb, Zn, Cu, and Ni and display a stronger antioxidant capacity than the green cabbage varieties.

Key words

purple cabbage, green cabbage, mineral content, vitamin C, total antioxidant capacity

Cabbage (*Brassica oleracea* or variants) is a leafy green biennial vegetable originating from wild cabbage (*Brassica oleracea* var. *oleracea*). It is used for its densely-leaved heads, which can be green, purple, and white (Wikipedia, 2012). According to USDA nutritional database 100 g of fresh cabbage leaves contain 5.8 g carbohydrates, 3.2 g sugars, 2.5 g dietary fibers, 0.1 g fat, 1.28 g protein, and provide 25 kcal of energy. Cabbage leaves are an ideal source of vitamins and essential trace elements. Thus, it is estimated that this vegetable provides 0.061 mg thiamine (vitamin B_1), 0.040 mg riboflavin (vitamin B_2), 0.234 mg niacin (vitamin B_3), 0.212 mg pantothenic acid (vitamin B_5), 0.124 mg pyridoxine (vitamin B_6), 53 µg folate (vitamin B_9), 36.6 mg acrobic acid (vitamin C) and 76 µg vitamin K per 100 g serving, that is between 2% and 72% from the daily RDA (i.e. Recommended Dietary Allowance) for these vitamins. Moreover, cabbage comprises important amounts of various micronutrients for human nutrition. A 100 g portion of fresh cabbage leaves supplies 40 mg calcium (Ca), 0.47 mg iron (Fe), 12 mg magnesium (Mg), 26 mg phosphorus (P), 170 mg potassium (K), and 0.18 mg zinc (Zn). The level to which cabage satisfy daily RDA for these microelements varies between 2% and 4% (USDA SR-21). Therefore, cabbage is extensively used in human nutrition, ranging from eating raw to steaming, pickling, braising, stewing, or sautening (Ingram 2000).

Cabbage has been used in popular medicine since Antiquity (Albert-Puleo, 1983). Several study authors shown that cabbage contains active compounds with antifungal, antibacterial, and anticancer activity (Kyung et al., 1997; Ye et al., 2011). MMTS, that is methaneothiosulfinate, has been demonstrated to function as an important antibacterial compound in fresh cabbage (Kyung and Fleming, 1994). Recently, a cyclophilin with antifungal activity was isolated from Chinese cabbage (*Brassica campestris* L. ssp. *pekinensis*) (Lee et al., 2007). Other investigations revealed that cabbage consumption can significantly decrease the risk of cancer development due to high content of sulphur compunds, such as sulforane (Farag and Motaal, 2010) or brassinin (Mehta et al., 1995). In addition, purple cabbage contains high amounts of anthocyanins, which are known to have an important role in cancer prevention (Wang and Stonner, 2008). Moreover, cabbage, especially the red one, is rich in catalase (Whitehead, 2012), which play an important role in human body antioxidant defence. Overall, cabage can be regarded not only as a valuable aliment, but also as miracle food for human health.

Romania was the 10th cabbage producers in the world in 2010 (Wiki, 2012). Cabbage consumption during the same year exceeded 10 kg per capita (INSSE, 2012), ranking Romania among the greatest cabbage markets in Europe. In this context, the present study aims at investigating the mineral content of several varietis of cabbage available on Romanian market. The total antioxidant capacity and vitamin C are taking into account as benchmarks to determine the antioxidant properties of each cabage variety.

Material and Methods

Sampling and preparation of cabbage leaves

Several varieties of cabbage were purchased from the local market: white cabbage of Buzău (abbr. WCB) from the supermarket; autochthonous white cabbage (abbr. WC1), the first sample, from the agricultural marketplace; autochthonous white cabbage (abbr. WC2), the second sample, from the agricultural marketplace; white cabbage from the supermarket (abbr. WCS); purple cabbage purchased from the supermarket (abbr. SPC); autochthonous purple cabbage (abbr. APC) from the agricultural marketplace. For each cabbage variety, three samples were collected from the cabbage meadow to prevent the deposition off potential air pollutants. The samples were weighed by using an analytical balance to the nearest 0.1 mg, and then oven dried at 105°C to constant weight. The dried samples were crushed by using a mortar, and passed through a 2 mm sieve; the samples were kept for further analysis at room temperature (t = 22°C).

Chemical analysis

The samples were digested in the muffle furnace. Prior to chemical analysis the ash was dissolved in 10 ml of 0.5 N HNO_3 sollution and filtered through ash-free filter paper. After that, the volume of each sample was brought to 50 mL with 40 mL of 0.5 N HNO_3 solution. Measurements of trace metal (Fe, Mn, Cd, Pb, Ni, Cu, Zn) in cabbage leaves were performed carried out in the laboratory (Environmental Research Test Laboratory, Banat`s University of Agricultural Sciences and Veterinary Medicine from Timisoara, Romania). Merck `Suprapur` nitric acid (65%, ρ = 1.39 g/cm3, Merck KGaA, Darmstadt, Germany) was used to prepare the digestion solutions, 0.5 N HNO3.The metal concentrations in the filtrate were determined by flame atomic absorption spectrophotometry with high resolution continuum source (Model ContrAA 300, Analytik Jena, Germany). Metal concentrations were shown as milligram per kilogram fresh weight (mg kg^{-1} f.w.). Double distilled water (spectroscopic pure) was used for the preparation of reagents and standards. All chemicals were trace metal grade (Suprapur). All glassware was treated with Pierce solution 20% (v/v), rinsed with cold tap water followed by 20% (v/v) nitric acid and then rinsed with double-distilled water. For quality control purposes all blanks and duplicate samples were analyzed during the procedure. NCS Certified Reference Material-DC 85104a and 85105a (China National Analysis Centre for Iron & Steel) was analyzed for quality assurance. The variation coefficients were below 10%. The blank reagent and standard reference soil were included into each sample batch to verify the accuracy and precision of the digestion procedure and also for subsequent analyses.

Statistical analysis

The principal component analysis (PCA) was used to find an appropriate approach for combining variables into a small number of subsets. Then, we performed a cluster analysis to classify the investigated cabbage varieties depending on their mineral content and antioxidant properties.

Table 1

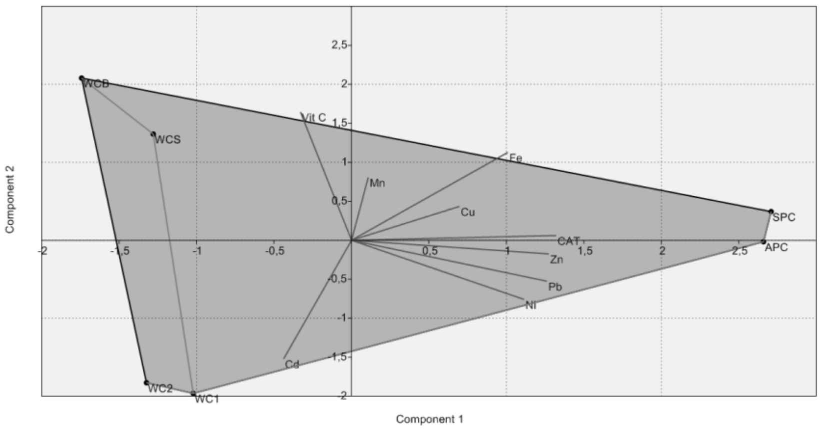
Mineral content and antioxidant properties in several varieties of cabbage

Cabage variety	Fe	Mn	Cd	Pb	Ni	Cu	Zn	Vit C	CAT
WCB	28.23	1.95	0.00	0.13	0.82	0.62	0.87	0.55	287.00
WC1	10.37	1.92	0.06	0.33	0.89	0.53	1.03	0.07	253.00
WC2	13.25	1.94	0.10	0.22	0.87	0.56	1.08	0.13	295.00
WCS	25.34	5.66	0.00	0.15	0.87	0.49	1.12	0.40	191.00
APC	36.90	3.23	0.00	0.50	0.91	0.62	1.39	0.23	726.00
SPC	37.23	2.87	0.02	0.47	0.92	0.60	1.41	0.24	756.00
MAL			0.10	0.50		5.00	15.00		

Results and Disscusions

Cu and Zn concentrations in cabage were shown to be lower than the maximum admitted level (MAL) in leafy vegetables (Table 1). Similar results were generally reported for Cd and Pb. However, there were several exceptions. Thus Cd level attained MAL value for WC2, and Pb for SPC. In the case of Pb, APC value was only slightly lower than MAL. Interestingly, purple cabage (i.e., APC, SPC) contained higher amounts of Pb and Zn than the white cabage. In addition, total antioxidant capacity (CAT) was much higher in red cabbage than in white cabbage, although the amounf of vitamin C varied widely among the investigated samples. It is considered that PCA scores are reliable only if the eigenvalues on the corresponding principal components are greater than one (55). In our case, the first three principal components, i.e. PC1, PC2, and PC3, satisfied this condition (Table 2). These components explained 97.448% of the total variance, with most being due to PC1. As shown in Table 2, concentrations of Fe, Pb, Ni, Cu, and Zn and antioxidant capacity revealed fairly high loadings on PC1, and therefore displayed a strong impact on PCA model. The association between canonical loadings of each variable and the canonical scores of each sample clearly showed that purple cabbage had high levels of Fe, Pb, Zn, Cu, Ni, and CAT. By contrast, white cabbage samples displayed reversed values of the aforemetioned parameters.

Graphical representation of the first two principal components indicated, as shown in Figure 1A, that Pb, Zn, and Ni concentrations and CAT levels were highly correlated with each other. Cu, Fe, and Mn content in cabbage leaves correlated moderately among themselves (Fig. 1A). It was therefore inferred that these two sets of variables share the same driving principle in defining the outcome of interest. Vitamin C and Cd concentration in cabbage exhibited reverse relationships with both sets of variables (Fig. 1A). Cabbage samples were classified into two main groups (r = 0.986). The first group contained purple cabbage varieties, whereas the second group included only green cabage varieties . These results clearly shows that mineral content, vitamin C level, and total antioxidant capacity in purple cabbage are different when compared to those found in green cabbage.



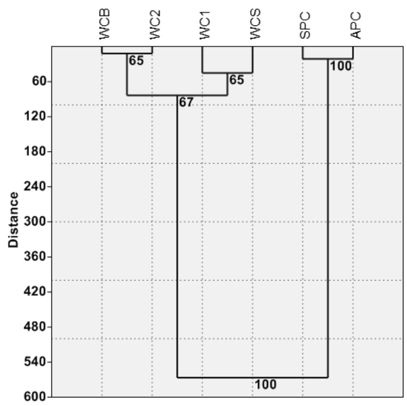


Fig. 1A. Principal component analysis for various cabbage varieties available on Romanian market.
Fig. 1B. Canonical cluster analysis for various cabbage varieties available on Romanian market.

Table 2

PCA results for various cabbage varieties available on Romanian market

PC	Eigenvalue	% variance	Case	Axis 1	Axis 2	Variable	Axis 1	Axis 2
1	4.376	48.628	**WCB**	-1.743	2.081	**Fe**	0.357	0.398
2	2.703	30.034	**WC1**	-1.022	-1.964	**Mn**	0.038	0.285
3	1.690	18.786	**WC2**	-1.324	-1.827	**Cd**	-0.155	-0.537
4	0.197	2.191	**WCS**	-1.280	1.362	**Pb**	0.446	-0.186
5	0.033	0.35965	**APC**	2.709	0.368	**Ni**	0.393	-0.268
			SPC	2.660	-0.019	**Cu**	0.246	0.153
						Zn	0.450	-0.062
						Vit C	-0.117	0.581
						CAT	0.467	0.022

Conclusions

Our results revealed that purple cabbage varieties tend to accumulate higher amounts of Fe, Pb, Zn, Cu, and Ni and display a stronger antioxidant capacity than the green cabbage varieties.

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