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# COMPOSITION AND ANTIOXIDANT ACTIVITY OF KALE (*BRASSICA OLERACEA* L. VAR. *ACEPHALA*) RAW AND COOKED

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## ABSTRACT

**Background.** Cabbage vegetables, like *Brassica* group, are perceived as very valuable food products. They have a very good nutritive value, high antioxidant activity and pro-healthy potential. Especially, kale (*Brassica oleracea* L. var. *acephala*) is characterized by good nutritional and pro-healthy properties, but this vegetable is not popular in Poland. The aim of this work was to assess the chemical composition and antioxidant activity of kale variety Winterbor $F_1$ and investigation of cooking process on selected characteristics.
**Material and methods.** The chemical composition and antioxidant activity were determined in leaves of kale Winterbor $F_1$ variety after three subsequent years of growing. In one season, analyses were performed on raw and cooked leaves.
**Results.** The investigated kale was characterized by high average contents of: β-carotene (6.40 mg/100 g f.m.), vitamin C (62.27 mg/100 g f.m.), alimentary fiber (8.39 g/100 g f.m.) and ash (2.11 g/100 g f.m.). The average amounts of nitrites (III) and (V) were 3.36 mg $NaNO_2$/kg f.m. and 1206.4 mg $NaNO_3$/kg f.m., respectively. The investigated kale contained polyphenolic compounds at average level of 574.9 mg of chlorogenic acid/100 g f.m., and its antioxidant activity measured as ABTS radical scavenging ability was 33.22 μM Trolox/g of fresh vegetable. It was observed a significant lowering of antioxidant compounds as a result of cooking. The losses of vitamin C were at about 89%, polyphenols at the level of 56%, in calculation on dry mass of the product. The highest stability was shown in the case of beta-carotene, for which the losses were at about 5%. Antioxidant activity of cooked vegetable lowered and reached the level of 38%. There were also some losses observed in macro-components from 13% for zinc to 47% for sodium. The contents of harmful nitrites and nitrates in calculation on dry mass were significantly lower as a result of cooking, by 67% and 78%, respectively.
**Conclusion.** Winterbor $F_1$ variety of kale has a great nutritive value and high antioxidant activity. The cooking process of kale resulted in lowering of the antioxidant activity of its antioxidants especially of vitamin C, polyphenols and to the lesser extent of β-carotene what confirms that vegetable should be eaten in raw form or just undergo little processing before consumption, for example blanching.

**Key words:** kale, chemical composition, antioxidant activity, cooking

## INTRODUCTION

Cabbage vegetables like *Brassica* group are perceived as very valuable food products. The research conducted, in many countries, corroborated the nutritive value, high antioxidant and pro-healthy potential of these vegetables. These vegetables are a precious source of fiber, mineral compounds, vitamin C,

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α-tokoferol and carotenoids (β-carotene, lutein). They are abundant of polyphenolic compounds and contain 15-20 different glucosinolates like compounds [Kurilich et al. 1999, Amin and Lee 2005, Ayaz et al. 2006, Heimler et al. 2006, Podsędek et al. 2006, Podsędek 2007, Singh et al. 2007, Cieślik et al. 2007, Sikora et al. 2008]. Chemical composition decides about the pro-healthy characteristics of these vegetables, especially as anticancerogenic [Beecher et al. 1994, Fahey et al. 1997, Verhoeven et al. 1997, Smith et al. 2003, Heimler et al. 2006].

The kale (*Brassica oleracea* L. var. *acephala*), is classified as *Brassicaceae*, known as cultivatory plant from ancient times, and notices about its cultivation in Poland are as old as XIVth century [Gapiński 1993]. Although it is not very popular in our country, often almost not known or perceived as a decorative plant [Whipker et al. 1998].

Kale finds favourable growing conditions in Poland, and because its morphological characteristics can be available as fresh for prevailing part of the year. Its cultivation demands a lot of water, but still the plant is resistant to drying. It also bears late autumn cold and frosts and the taste of its leaves is even better after being frozen, because of higher content of sugars and proteins. Nowadays, in Poland, the foreign cultivars of this vegetable are planted – two German: Halbhoher Grüner Mooskrauser, Niedriger Grüner Feinstgekrauster, three Dutch: Winterbor $F_1$, Redbor $F_1$ and Arsis $F_1$ [Skąpski and Dąbrowska 1994, Gapiński 1993, Kosterna and Wadas 2004].

The aim of this work was to assess the chemical composition and antioxidant activity of kale variety Winterbor $F_1$ and investigation of cooking process on selected characteristics.

## MATERIAL AND METHODS

### Material

The Winterbor $F_1$ kale variety (*Brassica oleracea* L. var. *acephala*) was used for investigations. The vegetable was grown up according to GAP at the "Polan" Plant and Horticultural Seed Production Centre Ltd. Krakow, Poland. The plants for assessments were collected in autumn during 3 subsequent years.

The leaves were firstly separated (5 kg green mass), then were tiny cut, mixed in order to obtain the representative average laboratory sample. A half of average sample was analysed for chemical composition as fresh and second half was lyophilized with a Christ Ralpha 1-4 freeze-dried and ground, using a Tecator Knifetec 1095 Sample Mill.

Half of fresh kale sample was cooked – fresh cold water spilled over, heated up to be boiled and kept in 100°C, for 12-15 min to obtain ready to eat consistency. The first part of cooked vegetable was directly analysed, after cooking while the second part was frozen and then lyophilized.

### Analytical methods

The following analyses were conducted on fresh and cooked kale:

- dry matter using the gravimetric method [AOAC 1995]
- the content of total ascorbic acid and dehydroascorbic acid using 2,6-dichlorophenoloindophenol and a spectrophotometric Tillman's method as modified by Pijanowski [Rutkowska 1981]
- β-carotene content with spectrophotometric method according to PN-90/A-75101/12
- nitrate and nitrite content according to Polish national standard [PN 92/A-75112] using spectrophotometric method.

Additionaly, metanol extracts were prepared (3 g of raw or 5 g of cooking vegetable in 80 $cm^3$ of 70% methanol solution which were used to establish the polyphenol content with the Folin-Ciocalteau reagent [AOAC 1995], as well as antioxidant activity by determining an ability to extinguish an ABTS free radical [Re et al. 1999].

In raw freshly and lyophilized kale the following analyses were performed:

- protein content using Tecator Kjeltec 2200 (calculation coefficient N×6.25)
- fat content, using Tecator Soxtec Avanti 2050
- ash content by dry mineralisation in muflon oven at 525°C
- dietary fiber content with enzymatic-gravimetry method according to AOAC [1995] using Tecator Fibertec System E
- contents of mineral compounds: Na, K, Ca, Mg, Zn, Cu, Mn.

Determination of mineral compounds contents i.e. calcium, magnesium, potassium and sodium was carried out with validated Atomic Absorption Spectrometry method with the atomization in the flame FAAS (Varian AA240FS of the Varian Company) according to the norm PN-EN 15505:2009. Determination of heavy metals content was carried out with validated Atomic Absorption Spectrometry method with the electrothermal atomization with graphite cuvette ET-AAS (Varian AA240Z of the Varian Company) according to the PN-EN 14084:2004.

The wet mineralisation of lyophilised kale was conducted with pressure microwave method (MarsXPres of the CEM company), with the nitric acid (Suprapur of the MERCK company catalogue No. 1.00441) given in the amount of 10 ml per 0.5 g of sample. The process of mineralisation was conducted in Teflon containers of 50 ml volume, where the maximum temperature of mineralisation was 200°C.

For assessment of potassium and sodium contents the buffer solution was applied according to Schuhknecht and Schinkel of the MERCK Company (catalogue No. 102037) in the amount of 2 ml per 50 ml mineralisate. For assessment of calcium and magnesium content the buffer solution was applied according to Schinkel of the MERCK (company catalogue No. 1.16755) in the amount of 10 ml per 50 ml. As part of the quality control of the method Certified Reference Materials NCS ZC 73009 was tested (China National Analysis Center for Iron and Steel).

Chemical analyses for each sample were repeated three times.

Also the percentage of carbohydrates was calculated on 100 g of fresh vegetable as the difference between 100 g of fresh product and the sum of water (%), total fat (%), protein (%) and mineral compounds – ash (%).

### Statistical analysis

To estimate the changes in chemical composition during 3 years of growing, and the influence on contents of selected components the ANOVA was used. The significance of differences was estimated with Duncan test at $p = 0.05$ (level of significance) with Statistica 7.1 software by StatSoft.

## RESULT AND DISCUSSION

### Nutrients and non-nutrients in raw leaves of kale

The chemical composition and antioxidant activity of raw kale harvested during 3 subsequent years of planting is presented in Table 1.

The dry mass (total solids) content obtained in raw leaves of assessed vegetable ranged from 16.75 to 17.39%. In the experiments by Łata and Wińska-Krysiak [2006] and Lisiewska et al. [2008] the similar results were obtained for the same variety of kale, 17.70 to 18.08% respectively. Other authors reported wider range of the above values: from 10.4% ±1.7% [Cao et al. 1996] to 35.6% depending on the term of harvest and on variety [Skąpski and Dąbrowska 1994]. Such differentiation in data can be explained as a result of a large variability of biological material for this species and as a result of external factors. It was stated that the later the term of kale harvest, the higher the dry matter content was. The similar phenomenon was presented in vegetable obtained from frozen cultivar what was explained as a result of freezing out water from leaves areas [Skąpski and Dąbrowska 1994].

The protein level in kale ranged from 3.97-4.37 g/100 g, what was in accordance with range of 2.4-9.6 g/100 g reported by other authors [Skąpski and Dąbrowska 1994, Ayaz et al. 2006]. The obtained results were higher than indexed data – 3.3 g of total protein in 100 g of edible parts of vegetable [Kunachowicz et al. 2005]. The biochemical varieties differentiation, agrotechnics and raining conditions have a great influence on total protein content. That content and composition depend on growing method, fertilization, kind and composition of soil [Almeida et al. 1996]. Eppendorfer and Søren [1996] reported that lackage of some mineral components (phosphorus and potassium) in soil influenced the amount and quality of protein in vegetable. Ayaz et al. [2006] and Lisiewska et al. [2008] found in protein of different kale varieties the biggest share of glutamine acid, proline and aspartic acid, and the smallest amounts of cysteine and methionine. The presence of the above and other exogenic aminoacids correspond to high nutritive value of kale protein.

The fat content in kale leaves was at average level of 0.67 g/100 g and differed significantly ($p < 0.05$) from values obtained for single subsequent year (0.67-

**Table 1.** Chemical composition and antioxidant activity of raw leaves of kale

| Component | Year of cultivar | | | Mean |
|---|---|---|---|---|
| | I | II | III | |
| Dry matter, % | 17.39 ±0.05 b | 16.79 ±0.35 a | 17.07 ±0.14 ab | 17.08 ±0.30 |
| Total protein, g/100 g | 4.14 ±0.03 ab | 3.97 ±0.23 a | 4.37 ±0.06 b | 4.16 ±0.22 |
| Fat, g/100 g | 0.66 ±0.01 a | 0.68 ±0.01 b | 0.67 ±0.02 ab | 0.67 ±0.01 |
| Ash, g/100 g | 2.18 ±0.11 a | 2.15 ±0.06 a | 2.00 ±0.12 a | 2.11 ±0.12 |
| Total carbohydrates, g/100 g | 10.41 a | 9.99 a | 10.03 a | 10.14 ±0.23 |
| Dietary fiber, g/100 g | 7.40 ±0.01 a | 9.56 ±0.12 c | 8.22 ±0.07 b | 8.39 ±1.09 |
| Vitamin C, mg/100 g | 52.25 ±1.40 a | 77.91 ±1.48 c | 56.64 ±1.89 b | 62.27 ±13.72 |
| β-carotene, mg/100 g | 6.84 ±0.26 b | 7.31 ±0.76 b | 5.05 ±0.26 a | 6.40 ±1.19 |
| Σ polyphenols, mg/100 g | 676.50 ±11.21 c | 544.86 ±6.54 b | 503.48 ±16.95 a | 574.95 ±90.35 |
| Na, mg/100 g | 42.7 ±0.02 c | 40.6 ±0.03 b | 32.4 ±0.02 a | 38.5 ±1.02 |
| K, mg/100 g | 501.5 ±0.03 c | 393.1 ±0.02 a | 419.7 ±0.03 b | 440.2 ±11.02 |
| Ca, mg/100 g | 380.7 ±0.05 b | 378.9 ±0.04 a | 394.8 ±0.05 c | 384.8 ±2.03 |
| Mg, mg/100 g | 37.1 ±0.02 c | 33.9 ±0.02 b | 33.7 ±0.01 a | 34.9 ±1.86 |
| Zn, mg/100 g | 0.86 ±0.02 b | 0.63 ±0.02 a | 0.99 ±0.03 c | 0.83 ±0.18 |
| Cu, mg/100 g | 0.06 ±0.01 b | 0.06 ±0.02 b | 0.02 ±0.01 a | 0.05 ±0.02 |
| Mn, mg/100 g | 0.91 ±0.03 c | 0.86 ±0.03 b | 0.80 ±0.02 a | 0.86 ±0.06 |
| Nitrites, mg $NaNO_2$/kg | 3.52 ±0.79 ab | 4.08 ±0.57 b | 2.50 ±0.10 a | 3.36 ±0.80 |
| Nitrates, mg $NaNO_3$/kg | 1 324.83 ±174.5 b | 1 214.50 ±68.4 ab | 1 079.80 ±17.6 a | 1 206.37 ±122.7 |
| Antioxidant activity, μm Trolox/g | 30.25 ±2.25 b | 22.02 ±0.13 a | 47.38 ±1.49 c | 33.22 ±12.94 |

a, b, c – mean with different letters in rows are statistically different at $p \leq 0.05$.

-0.68 g/100 g). According to bibliography data, the fat content in kale leaves may range from 0.4 to 1.3 g/100 g [Skąpski and Dąbrowska 1994].

Tables of food nutritional composition value showed that in kale fat may reach 0.7 g in 100 g [Kunachowicz et al. 2005]. According to Ayaz et al. [2006] mainly the α-linolenic (54% of the total fatty acid content), linoleic acid and palmitic acid are presented in kale leaves.

In the raw kale the carbohydrates were 10.14 g/100 g at average. As found in Polish bibliography data the amount of the carbohydrates ranges from 1.8-6.1 g/100 g in this vegetable [Skąpski and Dąbrowska 1994, Kunachowicz et al. 2005]. Whereas in the American literature [USDA Nutrient Database for Standard Reference] this value was up to 10.1 g/100 g, which is close to our results.

The basic part of carbohydrates in the assessed kale was fibre, which ranged from 7.40 to 9.56 g/100 g. According to literature the fibre content in kale should range from 0.8 to 3.8 g/100 g [Skąpski and Dąbrowska 1994, Kunachowicz et al. 2005]. These are mainly insoluble hemicelluloses and soluble pectin.

The ash content in leaves was at the level of 2.00--2.18 g/100 g. Among the estimated mineral component, considerable amounts of calcium, potassium and magnesium were established. Ayaz et al. [2006] reported that among kale's macroelements, the highest

levels of Ca and K and among microelements – iron, manganese and zinc (Table 1). The contents of the estimated minerals differed significantly dependently on the year of planting. Kopsell et al. [2004] who assessed 22 varieties of kale, found greatest differentiation for subsequent years concerned calcium, manganese and zinc. Almeida et al. [1996] showed codependence of some mineral components contents in kale leaves and soil mineral composition.

The vitamin C content estimated in raw leaves was from 52.25 to 77.91 mg/100 g. Amounts listed by other authors differed from our results and were rather higher than ours. The closest value (65.3 mg/100 g) was estimated by Grudzień [1984]. Skąpski and Dąbrowska [1994] reported a range from 100-300 mg/100 g placing this vegetable among rich in ascorbic acid sources, such as, green parsley or redpepper. Pfendt et al. [2003] reported the ascorbic acid at the level of 92.6 mg/100 g in kale. Davey et al. [2000] had obtained value at 186 mg/100 g, whereas in the tables, of food nutritional composition values [Kunachowicz et al. 2005] the level of 120 mg/100 g has been reported.

The β-carotene content ranged from 5.05-7.31 mg/100 g. Similar results were described by other authors [Skąpski and Dąbrowska 1994, Kopsell et al. 2004, Korus and Kmiecik 2007]. According to data by Kunachowicz et al. [2005], the content of this component was at the level of 5.35 mg/100 g, while Horbowicz and Saniewski [2000] reported the value of 9.2 mg/100 g. Other authors reported also big amounts of this component [Podsędek 2007]. Research of Kurilich et al. [1999] on different vegetables of Brassica oleracea family showed that kale was characterized by the highest content of β-carotene among them Winterbor $F_1$ had contained 6.08 mg/100 g of this component.

The sum of polyphenols estimated in raw kale was from 503.48 to 675.50 mg/100 g. The obtained values during 3 years period differed significantly ($p < 0.05$). In the research by Łata and Wińska-Krysiak [2006] the total polyphenols content in extracts (methanol: formic acid and distillated water), in kale Winterbor $F_1$ assessed spectrophotometically, calculated as gallic acid, was 202.1 mg /100 g. Manach et al. [2004] found the sum of polyphenols in kale at the level of 30-60 mg/100 g. Research of Heimler et al. [2006] showed that total polyphenols in Italian kale, estimated with FC reagent, was 138 mg/g dm. Ninfali and Bacchiocca [2003] reported that the plant genotype and its variety are meaningful factors influencing polyphenols content and antioxidant activity of vegetable at the same time. The term of plant harvesting [Hagen et al. 2009] may also have a significant influence. Polyphenols contents may be influenced by the conditions of initial (pre)treatment – peeling, cutting and grinding and resulting in lower antioxidant potential of plant material from 20 to 60% as compared to the whole raw plant. It is caused by activity of polyoxygenase [McCarthy and Mathews 1994].

Antioxidant activity measured as ability to scavenge the cationradical $ABTS^{+\cdot}$ ranged from 22.06-47.38 μM Trolox/g. The highest value was shown by extract prepared in the third year of research, and the lowest value was presented in those of previous year. The differences between subsequent means of all research years were significant ($p < 0.05$). Cao et al. [1996] assessed 22 vegetables and showed a large antioxidant activity of kale (17.7 μM Trolox/g for $ORAC_{ROO}$ and 6.2 μM Trolox/g for $ORAC_{OH\cdot}$). Their results allowed placing kale at first place among the assessed vegetables, including other *Brassica* (broccoli, cabbage, brussel sprout and cauliflower). The content of nitrites (III) estimated in raw leaves of kale ranged from 2.50-4.08 mg $NaNO_2$/kg. The amount of nitrates (III) in Winterbor $F_1$ kale variety obtained by Korus and Lisiewska [2009] was at average 0.17 $NaNO_2$/kg, what is obtained generally in freshly harvested vegetable, whereas during their storage after harvest the content of these compounds can grow. The content of nitrates (V) assessed in raw leaves of examined vegetable lowered in subsequent years of investigation and ranged from 1079.80-1324.80 mg $NaNO_3$/kg. The difference of nitrates (V) amount between the first and third year of research was significant ($p < 0.05$). The amount of nitrates (V) estimated by Korus and Lisiewska [2009] directly after harvest at the first week of September was 1326 mg/kg. Generally the level of nitrates (V) in kale is rather high, resulting from that kale is a leaf vegetable and both concentration and biotransformation, goes mainly in above growing part of plant. GAP demands the vegetable to be enriched in nitrogen during planting [Gapiński 1993]. Such an action quickens its growth (meaningfully) but applied in abundance can lead to surplus of nitrates in leaves.

In Table 2 are presented the amounts of selected compounds of raw and cooked kale.

Calculated on dry matter the contents of components such as: vitamin C, β-carotene, polyphenols, nitrates (III) and (V) selected metals (except zinc and manganese) and antioxidant activity in cooked kale were significantly lower ($p < 0.05$) than in raw vegetable (Table 2).

The losses of antioxidant components during cooking were as high as β-carotene and reached 89% for vitamin C. Also the antioxidant activity was meaningfully lowered – 38%. The losses of mineral compound were differentiated from 13% for zinc to 47% for sodium. However the differences of zinc and manganese contents between.raw and cooked vegetable were not significant. Cooking influenced contents of harmful nitrates (III) and (V) by lowering its values 67% and 78%, respectively, as calculated on dry mass.

In the experiment the cooking of kale started from pouring cold water over the vegetable, then the water was heated. In home practice it is the most frequent way of vegetables cooking which leads to greater looses of components than while pouring boiling water over the vegetable [Czarniecka-Skubina and Gołaszewska 2001]. Generally it is stated that water environment favours fast transfer of heat to whole product volume what causes longer contact with heat and all dimensions heating of the whole product mass. As a result of above large losses of some components can occur because of their thermal deterioration. On the other hand, changes connected with gentle and/or fast thermal treatment ($t < 100°C$) is perceived as favourable because of oxygen exploitation from solution, oxidoreductases group of enzymes denaturation (inhibited the enzymatic browning process) and heteroglicosides to aglicons hydrolysis. However, the loss of large portions of water soluble antioxidant compounds occurred, which are extracted from the tissues [Grajek 2003]. Washing up and subsequent degradation is also caused by long-term keeping up of boiling. This leads

**Table 2.** Effect of cooking on selected minerals content in leaves of kale, mg/100 g d.m.

| Component | Raw | Cooked | Percentage of loss |
|---|---|---|---|
| Vitamin C | 300.46 ±1.06 b | 33.46 ±0.23 a | 89 |
| β-carotene | 39.33 ±1.05 a | 37.44 ±5.37 a | 5 |
| Σ polyphenols | 3 890.2 ±64.5 b | 1 705.9 ±23.7 a | 56 |
| Antioxidant activity, μM Trolox/g d.m. | 173.9 ±12.9 b | 108.4 ±13.6 a | 38 |
| Minerals: | | | |
| Na | 245.5 ±0.3 b | 130.9 ±0.5 a | 47 |
| K | 2 883 ±0.3 b | 1 787 ±.05 a | 38 |
| Ca | 2 189 ±0.3 a | 2 221 ±0.5 a | +1 |
| Mg | 213.1 ±0.3 b | 174.5 ±0.5 a | 18 |
| Zn | 4.95 ±0.11 a | 4.31 ±0.19 a | 13 |
| Cu | 0.35 ±0.11 a | 0.39 ±0.19 a | +12 |
| Mn | 5.23 ±0.29 a | 5.43 ±0.48 a | +4 |
| Nitrates ($NaNO_3$) | 761.8 ±100 b | 163.6 ±18.2 a | 78 |
| Nitrites ($NaNO_2$) | 2.03 ±0.46 b | 0.68 ±0.11 b | 67 |

a, b, c – mean with different letters in rows are statistically different at $p \leq 0.05$.

to plant cells breaking and release of their content to the solution [Czarniecka-Skubina and Gołaszewska 2001]. Other research stated that the diminishing of antioxidants amounts can be accompanied by growth of their antioxidant activity.

This phenomenon is explained by easier accessibility of not degradable antioxidant compounds because of cell walls disruption [Nicoli et al. 1999]. Kalt [2005] reported similarly that carotenoids release from cell matrix causes growth of antioxidant activity and favours these compounds absorption in human intestinal tract. The influence of technological and culinary processes on antioxidant activity is not ultimately consistent. The following can be included into the group of unfavourable factors accompanying the mentioned technological treatment: oxidation, changes in composition of compounds, complexes forming, blocking of active centres, and conversion of antioxidant component form to prooxidant one [Grajek 2003].

Yadav and Sehgal [1995] showed that culinary treatment e.g. blanching can influence the loss of antioxidant components of leafy vegetables. Vitamin C losses in cooked kale were connected with washing out of that compound to the solution and stronger activity of ascorbinase in elevated temperature (40-70°C) [Czarniecka-Skubina and Gołaszewska 2001].

The same authors concluded that shortening of treatment time and diminishing of cooking water amounts favoured better preservation of vitamin C in vegetable. The large amounts of water led to lowering of that component content in brussel sprout from 28 to 39% and 14 to 41% in potatoes. Czerwińska [2003] found thermal treatment of leafy vegetables led to vitamin C reduction approximately about 70%. According to Howard et al. [1999] β-carotene can vanish because of tissues degradation in high temperature, paralelly the short blanching can stabilise this component. Zhang and Hamauzu [2004] observed that β-carotene losses during 30 min of broccoli cooking reached 45%. Puupponen et al. [2003] revealed that such processes like blanching and freezing practically do not influence that component content.

Kalt [2005] reported that polyphenol compounds can deteriorate during cooking process. It was confirmed by Gawlik-Dziki [2008]. Amin et al. [2005] found significant lowering of polyphenols compounds in leaves of vegetables just after one minute heating. Borowski et al. [2005], when assessing synthetic DPPH radical ability scavenging by broccoli depending on the type of thermal treatment, found that cooking in water lowered after few times the antioxidant activity of the involved compounds. Hunter and Flechter [2002] established that cooking in 95°C caused the antioxidant components of plants deterioration, whereas during more gentle hydrothermal treatment, such as blanching, the leaves vegetables lost at about 50% of their antioxidant activity. Kalt [2005] pointed that the susceptibility of antioxidative components during culinary processes diminished in row: ascorbic acid > phenolic compounds > carotenoids. It can be concluded that the influence of hydro-thermal process on polyphenols levels in vegetables depends on vegetable kind and process parameters.

## CONCLUSION

Winterbor $F_1$ variety of kale is a vegetable with great nutritive value first of all because of high content of vitamin C, β-carotene, nutritive fibre, phenolic compounds and macro- and microelements (compounds). The content of harmful nitrates (III) and (V) in raw vegetable is sometimes rather high but cooking causes their lowering. Fresh vegetable is characterized by high antioxidant activity, because of its composition. The cooking process of kale favours in meaningful way, lowering of antioxidant activity of its antioxidants especially of vitamin C, polyphenols and to the lesser extent of β-carotene what confirms that vegetable should be eaten as raw or low processed eg. after blanching.

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## SKŁAD I AKTYWNOŚĆ PRZECIWUTLENIAJĄCA JARMUŻU (*BRASSICA OLERACEA* L. VAR. *ACEPHALA*) SUROWEGO I GOTOWANEGO


### STRESZCZENIE

**Cel.** Warzywa kapustowate (*Brassicaceae*) są uważane za produkty bardzo wartościowe. Mają one dużą wartość odżywczą, wysoką aktywność przeciwutleniajacą i działanie prozdrowotne. Szczególnie jarmuż (*Brassica oleracea* L. var. *acephala*) charakteryzuje się wysokimi walorami odżywczymi i prozdrowotnymi, ale jest warzywem mało popularnym w Polsce. Celem podjętej pracy było zbadanie składu chemicznego i aktywności antyutleniającej jarmużu odmiany 'Winterbor $F_1$' oraz wpływu gotowania warzywa na wybrane składniki.
**Materiał i metodyka.** Zbadano skład chemiczny i aktywność przeciwutleniającą liści jarmużu pochodzącego z trzech kolejnych lat uprawy. W jednym z sezonów badawczych oznaczono wybrane składniki w liściach surowych i po ich ugotowaniu.
**Wyniki.** Badany jarmuż charakteryzował się wysoką średnią zawartością β-karotenu (6,40 mg/100 g), witaminy C (62,27 mg/100 g), błonnika pokarmowego (8,39 g/100 g) i popiołu (2,11 g/100 g). Średnia zawartość azotanów(III) i (V) wyniosła odpowiednio 3,36 mg $NaNO_2$/kg i 1206,4 mg $NaNO_3$/kg. Badany jarmuż zawierał związki polifenolowe na średnim poziomie 574,9 mg kwasu chlorogenowego/100 g, a jego aktywność przeciwutleniająca, mierzona zdolnością wygaszania rodnika $ABTS^{\bullet}$, wyniosła 33,22 μM Trolox/g świeżego warzywa. W wyniku gotowania jarmużu stwierdzono istotne zmniejszenie zawartości składników o właściwościach antyutleniających. W odniesieniu do suchej masy produktu straty witaminy C wyniosły ok. 89%, a polifenoli – ok. 56%. Największą stabilność wykazał β-karoten, którego straty w wyniku gotowania wyniosły tylko ok. 5%, Aktywność antyoksydacyjna warzywa ugotowanego uległa zmniejszeniu o 38%. Zaobserwowano również straty makroskładników, które były zróżnicowane – od 13% cynku do ok. 47% sodu. Zawartość szkodliwych azotanów i azotynów w suchej masie produktu uległa w wyniku gotowania istotnemu zmniejszeniu odpowiednio o ok. 67% i 78%.
**Wnioski.** Jarmuż odmiany 'Winterbor $F_1$' jest warzywem o dużej wartości odżywczej i zdrowotnej, przede wszystkim ze względu na dużą zawartość witaminy C, β-karotenu, błonnika pokarmowego, związków fenolowych oraz makro- i mikroelementów. Proces gotowania jarmużu w istotny sposób przyczynia się do zmniejszenia aktywności przeciwutleniającej i poziomu zawartych w nim antyoksydantów, szczególnie witaminy C i polifenoli, w mniejszym stopniu β-karotenu, co przemawia za tym, że warzywo to najlepiej spożywać w stanie surowym lub nisko przetworzonym, np. po blanszowaniu.


**Słowa kluczowe:** jarmuż, skład chemiczny, aktywność przeciwutleniająca, gotowanie

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