

## CONTENT OF NUTRITIVE COMPONENTS, DIETARY FIBRE AND ENERGY VALUE OF ARTICHOKE DEPENDING ON THE VARIETY

Iwona Mentel<sup>✉</sup>, Ewa Cieřlik, Izabela Wałkowska, Krzysztof Sieja

Malopolska Centre of Food Monitoring and Certification, University of Agriculture in Krakow  
Balicka 122, 30-149 Kraków, Poland

### ABSTRACT

**Background.** The artichoke (*Cynara scolymus* L.) is a perennial plant belonging to *Asteraceae* family. It is less popular vegetable in Poland but very valuable from nutritive and medicinal points of view plant.

**Material and methods.** The experiments were conducted in 2008 and 2009 on five artichoke varieties: 'Deutscher Hybrid', 'Emerald F<sub>1</sub>', 'Green Globe', 'Gros Camus de Bretagne' and 'Kerlouan', grew in Poland, France and Austria. The experimental material was assessed for: dry mass, protein, ash, vitamin C and dietary fiber contents and some mineral components (calcium, magnesium, phosphorus, potassium, sodium, iron, zinc) levels. Also the energy value and total carbohydrates content were calculated in the vegetable.

**Results.** Among assessed varieties, the highest contents of such components as: dry mass (total solids), carbohydrates, ash, vitamin C, sodium, potassium, magnesium, iron were found in 'Gros Camus de Bretagne'. The hearts of that artichoke had also higher energy value than others. Whereas the lowest ash, phosphorus, sodium, potassium and magnesium were noticed in 'Kerlouan' variety. But the highest values of dietary fiber was observed in that variety.

**Conclusions.** Basing on performed assessments the differences in nutritive components and dietary fiber, between analysed vegetable varieties were found.

**Key words:** artichoke, energy value, nutritive components and dietary fiber

### INTRODUCTION

The artichoke (*Cynara scolymus* L.) belongs to *Asteraceae* family and is classified in Cardue group. Most probably it originates from the Mediterranean Sea and Ethiopia regions, then it emigrated to Egypt. Nowadays it is perceived as cultivated vegetable only, and plantations are present, in a great scale in Western Europe: Italy, France, Spain and also in North America and Asia [Cieřlik et al. 2007]. Its appearance resembles thistle, its stalk is straight and covered with hairs, and it is 1.5 m high. The taproot is strongly developed, it has many tube flowers of indigo colour bristly down, formed in baskets [Cieřlik et al. 2007]. The edible part

of artichoke consists of fleshy bottom together with juicy pile leaves.

The artichoke is treated as one-year plant (because of long vegetation period). In Polish conditions it is grown from seedlings [Winiarska 2005]. The planting position of artichoke has to be hot and humid, protected from winds, with good sun exposition. It demands nutritive soils, humus with good ventilation keeping humidity [Cieřlik et al. 2007, De Vos 1992]. It is resistant to salt [Francois 1995]. This vegetable possesses great nutritive elements because of the organic and mineral supplementation of soil applied [Kordana

<sup>✉</sup>rrciesli@cyf-kr.edu.pl

et al. 1999]. The harvest of artichoke takes place from August to the end of September [Adzet et al. 1987, Bianco 2005, Clifford and Walker 1987].

The artichoke possesses very valuable nutritive and pro-health characteristics. It has comparably low-energy index ( $\sim 20$  kcal $\cdot 100$  g $^{-1}$  of fresh mass). It contains a wide variety of nutritive components: proteins, carbohydrates, vitamins (A, C, of B group) and also some minerals (calcium, magnesium, iron, phosphorus, sodium, potassium). It also contains the dietary fiber, especially: inulin and biologically active components: cynarin, acids (i.c. coffeic, chlorogenic), triterpens, flavonoids, sterols, tamins [Juzyszyn 2007].

This plant is used in homeopathic medicine, because of its pro-health value, as a bile and urine action regulator [Bianco 2007]. The artichoke is very tasteful and can be consumed as fresh, cooked, roasted, fried and stuffed, with additives, sauces [Winiarska 2006]. The aim of the study was to assess the dry mass, protein, ash, vitamin C and dietary fiber contents and some mineral components (calcium, magnesium, phosphorus, potassium, sodium, iron, zinc) levels. Also the energy value and total carbohydrates content were calculated in the vegetable.

## MATERIAL AND METHODS

The experimental material were hearts of 5 varieties of artichoke: 'Green Globe', 'Deutscher Hybrid' (Austria grown), 'Emerald F<sub>1</sub>' (Poland), 'Gros Camus de Bretagne' and 'Kerlouan' (France) planted in 2008 and 2009.

The material was washed up, dried and comminuted and then lyophilized. The determination of: protein, ash, dietary fiber, mineral components and vitamin C contents was done on lyophilized material. The dry mass content was done on fresh and lyophilized material. All obtained results were calculated on fresh mass basis.

The lyophilization process was done with CHRIST LOC-1M ALPHA 1-4 apparatus. The dry mass was obtained by drying method in dryer at 105°C during 24 h [Fortuna et al. 2003]. The protein content was performed by Dumas method with TruSpec N analyzer. The ash content was obtained by mineralization method with muffle oven at 525°C during 12 h [Fortuna et al. 2003]. The assessment of total carbohydrates

was done in accordance with methodology reported by Gronowska-Senger [2004].

The dietary fiber content was performed with AOAC 991.43 method. The energy value was calculated with average Atwater coefficients [Kunachowicz et al. 2005 a]. For calculations, the average  $-0,2$  g content of fat was used (according to bibliography). The vitamin C content was estimated as sum of ascorbic and dehydroascorbic acids [Krełowska-Kułas 1993].

To obtain the phosphorus content in artichoke, the spectrophotometric method with UV-vis detection and ammonium wanadomolybdate as dyeing agent, was used, with former sample mineralization in muffle oven in 525°C during 12 hours. The assessment of calcium, magnesium, potassium, sodium, iron and zinc was done by atomic absorption spectrometry (using AA240FS spectrometer) after microwave digestion (MARS Xpress, CEM).

The obtained results were submitted to statistical estimates with Statistica v. 5.1. The significance of differences between means was estimated with post-hoc Duncan test.

## RESULTS AND DISCUSSION

The total solids content in assessed artichokes ranged from 17.53 to 20.95 g $\cdot 100$  g $^{-1}$  of fresh mass basis. There were shown significant differences in total solids contents between assessed plant varieties (Table 1). The obtained results were in accordance with those reported by Praznik et al. [2004]. According to those authors, the total solids ranges from 15 to 18 g at average in fresh artichoke. Elmadfa and Muskat [2004] reported the level of 17.5 g, whereas Winiarska [2005] found the value to be 13.5 g.

Among the assessed artichoke varieties the highest protein value was found in 'Deutscher Hybrid' (3.08 g $\cdot 100$  g $^{-1}$  edible parts of plant; Table 1). A little bit values of that component was observed in 'Emerald F<sub>1</sub>' (3.07 g $\cdot 100$  g $^{-1}$  f.w.). There were no significant differences assessed between the above mean values of protein contents in those varieties. According to many authors [Cieřlik et al. 2007, De Vos 1992, Elmadfa and Muskat 2004], the levels of protein in fresh artichoke were 2.5 to 3 g. The lowest value of that component was characteristic for France originating variety – 'Gros Camus de Bretagne' (1.59 g $\cdot 100$  g $^{-1}$  f.w.).

**Table 1.** Content of nutritive and non-nutritive components and energy value of hearts selected varieties of artichoke cropped in 2008 and 2009 (mean value  $\pm$ SD)

Component	Variety				
	'Green Globe'	'Deutscher Hybrid'	'Kerlouan'	'Gros Camus de Bretagne'	'Emerald F <sub>1</sub> '
Energy value, kcal·100 g <sup>-1</sup>	17.20 $\pm$ 0.01 a	12.44 $\pm$ 0.01 b	16.27 $\pm$ 0.02 c	18.56 $\pm$ 0.02 d	17.57 $\pm$ 0.01 e
Dry mass, g·100 g <sup>-1</sup>	20.56 $\pm$ 0.02 a	17.53 $\pm$ 0.00 b	20.05 $\pm$ 0.04 c	20.95 $\pm$ 0.05 d	18.72 $\pm$ 0.02 e
Protein, g·100 g <sup>-1</sup>	2.17 $\pm$ 0.25 a	3.08 $\pm$ 0.23 b	1.81 $\pm$ 0.19 c	1.59 $\pm$ 0.02 c	3.07 $\pm$ 0.02 b
Carbohydrates, g·100 g <sup>-1</sup>	16.88 $\pm$ 0.10 a	12.97 $\pm$ 0.05 b	16.78 $\pm$ 0.03 a	17.40 $\pm$ 0.05 c	13.86 $\pm$ 0.00 d
Dietary fiber, g·100 g <sup>-1</sup>	11.27 $\pm$ 0.02 a	10.45 $\pm$ 0.03 b	14.65 $\pm$ 0.01 c	10.15 $\pm$ 0.03 d	8.60 $\pm$ 0.04 e
Ash, g·100 g <sup>-1</sup>	1.32 $\pm$ 0.04 a	1.27 $\pm$ 0.01 b	1.26 $\pm$ 0.01 b	1.76 $\pm$ 0.01 c	1.59 $\pm$ 0.01 d
Vitamin C, mg·100 g <sup>-1</sup>	7.09 $\pm$ 0.01 a	6.86 $\pm$ 0.01 b	8.43 $\pm$ 0.01 c	20.28 $\pm$ 0.01 d	15.47 $\pm$ 0.01 e

SD – standard deviation, a, b... – different letters in a row indicate significant differences between means at  $p < 0.05$ .

But difference between 'Gros Camus de Bretagne' and 'Kerlouan' artichokes was not significant for mean proteins levels.

The total carbohydrates contents in assessed varieties were 12.97-17.40 g. The literature data reported that this component in artichoke ranged from 7 to 15 g·100 g<sup>-1</sup> fresh matter [Elmadfa and Muskat 2004, Merrill and Watt 1975, Winiarska 2005]. The significance of statistical differences was not noticed for 'Green Globe' and 'Kerlouan', whereas other varieties differed significantly (Table 1).

The average value of dietary fiber was from 8.60 to 14.65 g·100 g<sup>-1</sup> edible parts of plant. According to De Vos [1992], Merrill and Watt [1975], the levels of dietary fiber in artichokes were 1.1 to 2.4 g·100 g<sup>-1</sup> of plant and Femenia et al. [1998] reported that value of the component in *Cynara scolymus* ranged from 56 to 99 g·kg<sup>-1</sup> fresh matter. The obtained results differed significantly between the assessed varieties.

Fortuna et al. [2003] reported that average ash content in fresh vegetables, ranged from 0.4 to 2.4 g·100 g<sup>-1</sup>. De Vos [1992] and Merrill and Watt [1975] pointed that ash content was at 0.8 g·100 g<sup>-1</sup> edible plant parts of artichoke level. The obtained results were much higher in comparison to De Vos and Merrill and Watt reports. The lowest levels were obtained for 'Kerlouan' artichoke (1.26 g) and 'Deutscher Hybrid' (1.27 g). There were no significant differences noticed

between the above varieties. The highest value of ash was noticed in 'Gros Camus de Bretagne' variety (1.76 g; Table 1).

The artichoke belongs to a vegetable group with low energy level supply. The energy value of five varieties of artichoke submitted to assessments ranged from 12.44 to 18.56 kcal·100 g<sup>-1</sup> of edible parts. There were shown significant differences in energy value for all artichoke varieties. These values were found to be lower than those obtained by Cieřlik et al. [2007], Elmadfa and Muskat [2004] and Gumowska [1976].

There were shown significant differences in vitamin C levels between the varieties. The highest vitamin C content was found in 'Gros Camus de Bretagne' variety – 20.28 mg·100 g<sup>-1</sup> of fresh vegetable. Almost 3-times lower amount of that component was found in 'Deutscher Hybrid' variety – 6.86 mg·100 g<sup>-1</sup>. All the assessed varieties differed statistically. Cieřlik et al. [2007] reported the average vitamin C at 8 mg·100 g<sup>-1</sup> level. Gumowska [1976] found this component value to be 10 mg. As Grajek [Przeciwiutleniacze... 2006] reported the vitamin C content was greatly influenced by differences in variety, climate and agrotechnics differences and also harvest time and kind of fertilization applied.

All varieties contained outstandingly low calcium levels (29.05-44.34 mg) in comparison to results obtained by other authors. According to Gumowska

[1976] the macroelement content in fresh artichoke heart was 50 mg. De Vos [1992], Cieřlik et al. [2007], Merrill and Watt [1975] and Winiarska [2005] reported value of 51 mg of calcium and Elmadfa and Muskat [2004] – 53 mg·100 g<sup>-1</sup> of plant. The closest amount of calcium to our results in fresh artichoke was found in ‘Deutscher Hybrid’ – 44.34 mg. All the assessed varieties differed significantly concerning the average calcium amounts.

In ‘Gros Camus de Bretagne’ variety artichoke the highest value of magnesium was found – 71.81 mg·100 g<sup>-1</sup> of edible parts. The second place was taken by ‘Emerald F<sub>1</sub>’ variety – 51.20 mg. The other hearts of the assessed artichokes contained significantly lower levels of that component – ‘Kerlouan’ – 32.42 mg, ‘Green Globe’ – 34.83 mg and ‘Deutscher Hybrid’ – 36.23 mg. Elmadfa and Muskat [2004] reported the level of 25-26 mg·100 g<sup>-1</sup> fresh artichoke, whereas other literature data [Ocean... 2008, United... 2007] found the value to be 0.6 mg·g<sup>-1</sup> fresh matter. The significant differences for that element found between the assessed varieties are presented in Table 2.

All the varieties were characterised by high potassium (433.89-581.23 mg·100 g<sup>-1</sup>) levels, where the highest content was noticed in ‘Gros Camus de Bretagne’ hearts (581.23 mg·100 g<sup>-1</sup> fresh mass). Similarly, as for magnesium, significant differences in potassium average contents were found between

varieties. As the bibliography [Cieřlik et al. 2007, De Vos 1992, Elmadfa and Muskat 2004, Merrill and Watt 1975, Ocean... 2008, United... 2007, Winiarska 2005], the average content of this macroelement ranges from 310-430 mg·100 g<sup>-1</sup> of edible parts.

Three among the assessed artichoke varieties contained similar amounts of phosphorus (‘Gros Camus de Bretagne’ – 70.40 mg, ‘Green Globe’ – 72.65 mg and ‘Deutscher Hybrid’ – 74.55 mg·100 g<sup>-1</sup> fresh matter). The obtained amounts were close to those reported by Cieřlik et al. [2007] and Winiarska [2005]. They found the phosphorus level for artichoke to be 69 mg. De Vos [1992] stated the phosphorus value for 88 mg. The highest content of that element was reported by Elmadfa and Muskat [2004] at 130 mg level. Among the assessed varieties, only one was characterised by a higher level of phosphorus – ‘Emerald F<sub>1</sub>’ (118 mg·100 g<sup>-1</sup> edible parts). The statistical tests showed significant differences in phosphorus content between the varieties (Table 2).

Only one of artichoke varieties – ‘Gros Camus de Bretagne’ was characterised by sodium level (48.13 mg·100 g<sup>-1</sup> fresh mass) similar to data of other researchers. According to Elmadfa and Muskat [2004] and Merrill and Watt [1975] that macroelement content in artichokes was from 43 to 47 mg. Whereas in other reports [Cieřlik et al. 2007, Winiarska 2005] the value is lower – 30 mg. The rest of varieties of the

**Table 2.** Content of mineral components in hearts of selected varieties of artichoke cropped in 2008 and 2009 (mean value ±SD)

Component	Variety				
	‘Green Globe’	‘Deutscher Hybrid’	‘Kerlouan’	‘Gros Camus de Bretagne’	‘Emerald F <sub>1</sub> ’
Calcium, mg·100 g <sup>-1</sup>	29.05 ±0.03 a	44.34 ±0.04 b	33.86 ±0.01 c	35.03 ±0.03 d	31.55 ±0.01 e
Magnesium, mg·100 g <sup>-1</sup>	34.83 ±0.03 a	36.23 ±0.02 b	32.42 ±0.02 c	71.81 ±0.01 d	51.20 ±0.01 e
Potassium, mg·100 g <sup>-1</sup>	493.61 ±0.03 a	440.49 ±0.01 b	433.89 ±0.02 c	581.23 ±0.01 d	435.75 ±0.02 e
Phosphorus, mg·100 g <sup>-1</sup>	72.65 ±0.01 a	74.55 ±0.01 b	51.45 ±0.01 c	70.40 ±0.02 d	118.00 ±1.00 e
Sodium, mg·100 g <sup>-1</sup>	9.24 ±0.02 a	12.76 ±0.01 b	3.77 ±0.02 c	48.13 ±0.03 d	8.73 ±0.01 e
Iron, mg·100 g <sup>-1</sup>	0.64 ±0.02 a	0.71 ±0.06 ab	0.74 ±0.05 b	3.36 ±0.02 c	1.22 ±0.04 d
Zinc, mg·100 g <sup>-1</sup>	0.95 ±0.03 a	0.70 ±0.01 b	0.65 ±0.04 b	0.31 ±0.04 c	0.32 ±0.02 c

SD – standard deviation, a, b... – different letters in a row indicate significant differences between means at p < 0.05.

assessed artichoke contained small amounts of sodium ranging from 3.77 to 12.76 mg. There were significant differences shown in sodium content between artichokes' hearts analysed.

The average iron content in artichokes is between 1.1 to 1.6 mg·100 g<sup>-1</sup> edible parts [De Vos 1992, Elmadfa and Muskat 2004, Winiarska 2005]. In 'Emerald F<sub>1</sub>' variety the iron content was similar to the above mentioned. In the other, three varieties significantly lower levels of that element were found. For 'Green Globe', 'Deutscher Hybrid' and 'Kerlouan' the average iron content ranged from 0.64 to 0.74 mg·100 g<sup>-1</sup> fresh material. For French 'Gros Camus de Bretagne' variety the content of the component was higher in comparison to others (3.36 mg·100 g<sup>-1</sup> fresh material). There were no significant differences found in between 'Green Globe' and 'Deutscher Hybrid' and also 'Deutscher Hybrid' and 'Kerlouan' artichokes.

The hearts of the assessed artichoke varieties differed in zinc (0.31-0.95 mg·100 g<sup>-1</sup> of edible parts) contents. The smallest amounts of zinc were observed in 'Gros Camus de Bretagne' and 'Emerald F<sub>1</sub>'. There were no significant differences noticed between those two varieties and also between 'Deutscher Hybrid' and 'Kerlouan' varieties (Table 2). Kunachowicz et al. [2005 b] reported that zinc content in green salad is around 0.44 mg·100 g<sup>-1</sup> of fresh product.

The abundance of nutritive components in artichoke, such as: proteins, carbohydrates, mineral components and vitamins allows to conclude that it is not only a vegetable but precious homeopathic herbal medicine with great pro-healthy features [Cieřlik et al. 2007]. The presence of non-nutritive components such, as for example, fiber, causes that the vegetable when consumed plays an important role in digestive tract regulation stimulating its peristalsis, for owing proper digestion, counteracts constipations [Abad Alegria and Gonzalez Vivanco 2004, Wolver 1990]. It combines sodium ions allowing for lowering of blood pressure [řwiderski et al. 2001]. Because of fructans presence it shows prebiotic activity. Fructans modify guts microflora, favour the *Lactobacillaceae* microflora growth and influence significantly on lowering of blood glucose concentration, on bioavailability of some mineral components, inter alia of calcium [Abad Alegria and Gonzalez Vivanco 2004, Cieřlik et al. 2007, Flamm et al. 2001, Schützt et al. 2006, Wolver

1990]. The low caloric value of artichoke allows for obesity fighting persons consumption.

Nowadays artichoke is applied in prevention of such diseases as: hypercholesterolemia and in guts diseases [Karłowicz-Bodalska and Bodalski 2007]. The important characteristics of this vegetable are its antioxidative abilities. They play an important role in free radicals scavenging, thanks to it they have a specific value in cancer cure and also show an antiarteriosclerosis effect.

## CONCLUSIONS

1. The biggest contents of basic components: total solids, total carbohydrates, ash, vitamin C, sodium, potassium, magnesium, iron were present in 'Gros Camus de Bretagne' variety.

2. The mineral components content was the highest in hearts of 'Deutscher Hybrid' (calcium), 'Emerald F<sub>1</sub>' (phosphorus) and 'Green Globe' (zinc).

3. All artichoke varieties were characterised by a high dietary fiber content.

4. 'Gros Camus de Bretagne' variety had the highest energy value.

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## WARTOŚĆ ENERGETYCZNA ORAZ ZAWARTOŚĆ SKŁADNIKÓW ODŻYWCZYCH I NIEODŻYWCZYCH KARCZOCHA W ZALEŻNOŚCI OD ODMIANY

### STRESZCZENIE

**Wprowadzenie.** Karczoch (*Cynara scolymus* L.) to roślina wieloletnia, należąca do rodziny *Asteraceae*. Jest warzywem mało rozpowszechnionym, ale wartościowym pod względem zarówno odżywczym, jak i leczniczym.

**Materiał i metody.** Doświadczenia przeprowadzono w latach 2008 i 2009 z udziałem pięciu odmian karczocha: 'Deutscher Hybrid', 'Emerald F<sub>1</sub>', 'Green Globe', 'Gros Camus de Bretagne' i 'Kerlouan' uprawianych na terenie Polski, Francji i Austrii. W materiale wykonano oznaczenie zawartości suchej masy, białka, popiołu, witaminy C, błonnika pokarmowego, a także składników mineralnych (wapń, magnez, fosfor, potas, sód, żelazo, cynk). Ponadto określono w warzywie wartość energetyczną i poziom węglowodanów ogółem.

**Wyniki.** Spośród badanych odmian, 'Gros Camus de Bretagne' charakteryzowała się największą zawartością składników takich, jak: sucha masa, węglowodany, popiół, witamina C, sód, potas, magnez, żelazo. Serca tego karczocha odznaczały się również większą wartością energetyczną. Natomiast najniższy poziom popiołu, fosforu, sodu, potasu i magnezu odnotowano w odmianie 'Kerlouan'. Jednakże w tej odmianie zaobserwowano największą wartość błonnika.

**Wnioski.** Na podstawie przeprowadzonych badań wykazano różnice w zawartości składników odżywczych i nieodżywczych pomiędzy odmianami poddanymi analizom.

**Słowa kluczowe:** karczoch, wartość energetyczna, składniki odżywcze, składniki nieodżywcze

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