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THE EVALUATION OF QUALITY OF SELECTED CULTIVARS OF PARSLEY (*Petroselinum sativum* L. ssp. *crispum*)

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Abstract. Parsley leaves are the most valuable vegetables owing to its biological properties. They are a very rich source of vitamin C, β-carotene and mineral constituents. The study aim of the present work was to evaluate yield and quality of three cultivars of leafy parsley: 'Amphia', 'Festival' and 'Verta'– a leaf cultivar. In the experiment conducted in 2009–2010 the yield of leaves for unit of area and an influence of conservation method (freezing, drying) for content of active compounds were determined. The raw material was harvested in two terms: in the second ten days of August and second ten days of September. The content of essential oils, flavonoids, polyphenolic acids, vitamin C, carotenoids, and chlorophyll were determined in all kinds of raw material. The yield of leaves per 1 m^2 was on average from 0.55 kg to 3.57 kg. Higher mass of leaves was obtained at the second term of harvest for all investigated varieties. Among the compared cultivars 'Amphia' produced higher yields than others (2.61 $kg \cdot m^{-2}$). The content of biologically active compounds in the leaves of parsley significantly depended on the variety, date of harvest and method of conservation. The content of assimilate pigments and vitamin C in leaves of parsley clearly decreased under the influence of freezing and drying (in the case of vitamin C drying completely degraded the vitamin). Freezing reduced the essential oil content and polyphenolic acids in the leaves of parsley, drying increased the content of these components.

Key words: leafy parsley, yield, stabilization method, essential oil, flavonoids, polyphenolic acids

INTRODUCTION

Parsley is a popular spice plant known from antiquity. Both parsley root, and leaves are a widely used culinary, medicinal and aromatic plant. The fresh or dried leaves are used in the food, cosmetic and pharmaceutical industries to produce spice, essential oils

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and drugs [Lopez et al. 1999]. In food preparation, the fresh parsley leaves are also used as a garnish and for seasoning. The dried leaves known as parsley flakes are particularly used in the instant food sector as an ingredient to flavour soups and sausages. It is a very rich source of vitamins C and E, β-carotene, thiamin, riboflavin and organic minerals [Bąkowski and Michalik 1986; Wills et al. 1986; Michalik and Dobrzański 1987, Kołota 2011]. It is used as a carminative, diuretic, hypertensive, hypotensive, stomachic, nervine, emmenagogic, abortifacient and nutritive agent [Kreydiyyeh and Usta 2002]. As a traditional medicine for diabetes, parsley has been used in the world [Noel et al. 1997, Yanardag et al. 2003]. The hypoglycemic activity of parsley has been investigated in many studies. Phytochemical screening of parsley has revealed the presence of flavonoids such as apiin, luteolin, and apigenin glycosides [Fejes et al. 2000], carotenoids [Francis and Isaksen 1989], ascorbic acid [Davey et al. 1996], tocopherol [Fiad and El Hamidi 1993], volatile compounds (myristicin, apiole), coumarines (bergapten, imperatorin [Fejes et al. 2000], phthalides, furanocoumarins, and sesquiterpenes [Spraul et al. 1991]. Parsley like many other herbs is highly seasonal in nature. In order to preserve this seasonal and highly perishable plant and make it available to consumers all year round at low prices, it is subjected to post-harvest technological treatments such as drying and freezing. Drying is one of the oldest methods of food preservation and represents very important aspect of food processing [Doymaz et al. 2006]. Natural drying (drying in the shade) and hot air drying are still most widely used methods to produce dried parsley flakes, because of their low cost. Natural drying has many disadvantages due to the inability to handle the large quantities and to achieve consistent quality standards [Soysal and Öztekin 2001]. The freezing of parsley leaves, particularly as pressed cubes, ensures their easy, rapid, and wide application at home and in restaurants.

In spite of many advantages an economic importance of parsley (*Pertoselinum sativum* L. ssp. *crispum*) in Poland is still low. Leaves harvested mainly from tuber rooted parsley provide significantly lower yield compared to leafy parsley [Kmiecik and Lisiewska 1999].

The aim of the presented work was to determine the quality and yield three cultivars of the parsley.

MATERIAL AND METHODS

The study on cultivation of three leafy type cultivars of parsley; ‘Amphia’, ‘Festival’ and ‘Verta’ were carried out in 2009–2010 in the experimental field of Department of Vegetables and Medicinal Plants in Wilanów. The field experiments were carried out by using randomized blocks method with four replications, on the heavy alluvial soil. The first factor was the parsley cultivars, the second are included two terms of harvest and third one the method of conservation (freezing and drying). Before seed sowing there was applied: 40 kg P as triple superphosphate and 150 kg K in the form of potassium chloride per 1 ha. Nitrogen was used in the amount of 40 kg·ha^{-1} as a preplant dose and 30 kg N·ha^{-1} as top dressings in the sixth and tenth week of growing plants, in the form of ammonium nitrate.

Seeds of three of parsley cultivars were sown in subsequent years of research in the first decade of April. A single plot area was 5 m^{-2}. On witch were grown 40 plants per 1 m^{-2}. During vegetation manual weeding of plant was performed several times, as well as constants watering, by means of dripping lines. The thermal conditions during the experiment were generally favourable for the growth of parsley. The mean air temperature during vegetation of the examined plants was similar to the multiannual mean.

The rosettes leaves (raw material) were collected in two terms: in the second ten days of August and one month later. After harvesting the fresh mass of herb was determined and next the raw material was divided into three parts: chemical analysis were carried out in the first part of the fresh raw material, the second part of raw material was dried in dryer chamber ('Leśniczanka' type) at temperature of 35°C (until a 14% humidity, air velocity was kept at 1.1 m/s) and stored in hermetically closed paper bags in airy dry place till the moment of performing of quality analysis, the third part of the herb was frozen. Freezing was performed in two stages: raw material directly after collecting was chopped, placed in plastic bags and held at temperature -80°C by period of 48 hours, next the bags were moved to a freezer, where the temperature -25°C was kept.

The chemical analysis were carried out on fresh, frozen and dried raw material in the Department's laboratories. The content of essential oil and flavonoids were determined according to a method described in Polish Farmacopoea VI [2002], carotenoids, and chlorophyll (a + b) by Lichtentchaller and Gelbryn [1983], vitamin C by Polish Norm (PN-90/A-751001/11), polyphenolic acids by Polish Norm (PN-91/R-870/9). For dried and frozen raw material analysis were made three month after it conservation. Analyses of the content of each component were carried out in four replications (in two parallel samples).

The results presented are the average of two years of research.

Statistical analyses. Data on the yield and chemical composition were subjected to statistical analysis using statistical program Statgraphics Plus 4.1. The analysis of variance followed by Tukey's multiple range test was employed and the differences between individual means were deemed to be significant at $\alpha = 0.05$.

RESULTS AND DISCUSSION

The parsley is a plant that belongs to the celery family, *Apiaceae*. The three main types of parsley are the plain leaf type and the curly leaf type, which are cultivated for their foliage, and the turnip-rooted type, primarily grown for its roots [Petropoulos et al. 2004]. The fresh and dried leaves are widely used as flavouring in many different food products on account of its powerful aromatic odour. The essential oils obtained from the herb and from the seeds, are also used as flavours, mainly as fragrances in perfumery.

Results of the study shown as the means for two years of field experiment indicate a significant impact of all tested factors on yield and quality of leafy parsley. The term of harvest and the cultivar of parsley had the significant influence on the yield of leaves (tab. 1) witch on the average amounted to 1.84 $kg \cdot m^{-2}$. Regardless of the years of research obtained crop size depended on the time of harvest. Really higher yield of leaves was obtained at second term of harvest for all investigated varieties (mean 2.35 $kg \cdot m^{-2}$).

There was a significant difference between the cultivar and amount of green mass yield of parsley. Among the compared cultivars 'Amphia' produced higher yields than others (2.61 kg·m^{-2}). It fits to the level indicated by Dyduch and Jankowska, (2004) 1.2–2.5 kg·m^{-2}.

Table 1. Fresh weight of leaves of parsley (mean for 2009–2010) (kg·m^{-2})
Tabela 1. Świeża masa liści pietruszki (średnio za lata 2009–2010) (kg·m^{-2})

Cultivar Odmiana	Term of harvest Termin zbioru		Mean Średnia
	August sierpień	September wrzesień	
'Amphia'	1.64ab[1]	3.57a	2.61a
'Festival'	1.83a	2.39ab	2.11b
'Verta'	0.55c	1.09c	0.82c
Mean Średnia	1.34b	2.35a	1.84

[1]Means signed with the same letters do not differ significantly
[1]Średnie oznaczone tymi samymi literami nie różnią się statystycznie

The natural dyes are important compound of leaf vegetables. They determine the appearance of both raw material and its biological value [Piagentini et al. 2002]. Chlorophylls are the least stable dyes, therefore gaining the processed product in natural green colour is very difficult. Dried parsley should have a bright green colour; hence it should be dried quickly in order to inactivate the enzyme chlorophylls which breaks down chlorophyll turning the leaf yellow [Fraser and Whish 1997]. The content of chlorophyll in the analyzed plant material depended significantly on the term of harvest, the cultivar and the method of stabilization (tab. 2). The higher content of chlorophyll (a + b) was determined in leaves harvested in August (3.36 mg·100 g^{-1}). In the leaves of the cultivar 'Vetra' the highest amount was determined (4.35 mg·100 g^{-1}). The loses of chlorophyll was noted in leaves of the cultivar 'Amphia'(1.91 mg·100 g^{-1}). The decisive factor influencing the colour of frozen parsley leaves is their chlorophyll content [Lisiewska and Kmiecik 1997]. Results of this study showed that drying process had more negative effect on the quantity of chlorophyll than freezing.

Also in the second group of assimilate pigments – carotenoids, clearly destructive influence of used preservation methods for this parameter were observed. Taking into account the main results, content of above pigments decreased of three times in the case of freezing. These results are different from the data that gives Lisiewska et al. [2004] for dill, whereby the freezing only minimally reduces the content of this group of compounds. The drying process was even more unfavorable for carotenoids, because in its effect more than six times less of these compounds (tab. 3) was achieved.

The most important biological compound of parsley leaf is vitamin C [Bąkowski and Michalik 1986, Wills et al. 1986, Grzeszczuk et al. 2005, Kołota 2011]. Due to its seasonal nature the processing, preserving and storing are crucial. In nutritional practice the

Table 2. Content of chlorophyll (a + b) in leaves of parsley (mean for 2009–2010) (mg·100 g^{-1})
Tabela 2. Zawartość chlorofilu (a + b) w liściach pietruszki (średnio za lata 2009–2010) (mg·100 g^{-1})

Cultivar Odmiana	Fresh leaves Liście świeże			Frozen leaves Liście mrożone			Dry leaves Liście suche		
	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia
	August sierpień	September wrzesień		August sierpień	September wrzesień		August sierpień	September wrzesień	
'Amphia'	2.24c[1]	1.57c	1.91c	2.07c	1.56b	1.82b	2.03b	1.85b	1.94b
'Festival'	3.70b	3.45b	3.58b	3.97a	3.57a	3.77a	2.01b	1.96b	1.99b
'Verta'	4.16a	4.54a	4.35a	2.83b	3.58a	3.20ab	2.87a	2.01ab	2.44a
Mean Średnia	3.36a	3.15b	3.28	2.96a	2.90a	2.91	2.30a	1.94a	2.12

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Table 3. Content of carotenoids in leaves of parsley (mean for 2009–2010) (mg·100 g^{-1})
Tabela 3. Zawartość karotenoidów w liściach pietruszki (średnio za lata 2009–2010) (mg·100 g^{-1})

Cultivar Odmiana	Fresh leaves Liście świeże			Frozen leaves Liście mrożone			Dry leaves Liście suche		
	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia
	August sierpień	September wrzesień		August sierpień	September wrzesień		August sierpień	September wrzesień	
'Amphia'	3.57a[1]	1.64a	2.61a	0.69a	0.36c	0.53b	0.56a	0.08b	0.32a
'Festival'	1.57c	1.66a	1.61b	0.49b	0.58b	0.54b	0.23c	0.31a	0.27b
'Verta'	1.65c	1.43b	1.54b	0.46b	1.07a	0.77a	0.34b	0.27ab	0.31ab
Mean Średnia	2.26a	1.58b	1.92	0.55a	0.67a	0.61	0.38a	0.22b	0.30

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Table 4. Content of C vitamin in leaves of parsley (mean for 2009–2010) (mg·100 g^{-1})
Tabela 4. Zawartość witaminy C w liściach pietruszki (średnio za lata 2009–2010) (mg·100 g^{-1})

Cultivar Odmiana	Fresh leaves Liście świeże			Frozen leaves Liście mrożone			Dry leaves Liście suche	
	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru	
	August sierpień	September wrzesień		August sierpień	September wrzesień		August sierpień	September wrzesień
'Amphia'	96.88bc[1]	100.02c	98.45c	10.06c	8.66c	9.36b	trace	trace
'Festival'	312.70a	269.30a	291.00a	23.30b	36.30a	29.80a	trace	trace
'Verta'	119.60b	215.30b	167.40b	47.10a	23.60ab	35.30a	trace	trace
Mean Średnia	176.40a	194.87a	185.62	26.82a	19.71a	22.85	-	

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Table 5. Content of essential oil in leaves of parsley (mean for 2009–2010) (ml·100 g^{-1})
Tabela 5. Zawartość olejku eterycznego w liściach pietruszki (średnio za lata 2009–2010) (ml·100 g^{-1})

Cultivar Odmiana	Fresh leaves Liście świeże			Frozen leaves Liście mrożone			Dry leaves Liście suche		
	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia
	August sierpień	September wrzesień		August sierpień	September wrzesień		August sierpień	September wrzesień	
'Amphia'	0.14b[1]	0.11b	0.13ab	0.08a	0.08a	0.080b	0.07c	0.07c	0.07b
'Festival'	0.18a	0.12b	0.15a	0.07b	0.06b	0.065c	0.20a	0.23a	0.22c
'Verta'	0.17a	0.14a	0.15a	0.09a	0.09a	0.090a	0.16b	0.18b	0.17a
Mean Średnia	0.16a	0.12b	0.14	0.08a	0.08a	0.078	0.14a	0.16a	0.15

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[1]Średnie oznaczone tymi samymi literami nie różnią się statystycznie

Table 6. Content of polyphenolic acids in leaves of parsley (mean for 2009–2010) (mg·100 g^{-1})
Tabela 6. Zawartość kwasów polifenolowych w liściach pietruszki (średnio za lata 2009–2010) (mg·100 g^{-1})

Cultivar Odmiana	Fresh leaves Liście świeże			Frozen leaves Liście mrożone			Dry leaves Liście suche		
	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia
	August sierpień	September wrzesień		August sierpień	September wrzesień		August sierpień	September wrzesień	
'Amphia'	70b[1]	3c	37b	26b	21a	24ab	160a	130b	145a
'Festival'	100ab	20a	60a	40a	10b	28a	150b	150a	150a
'Verta'	130a	10b	70a	30ab	10b	23ab	130c	120c	125b
Mean Średnia	100a	11b	55	32a	14b	25	147a	133b	140

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Table 7. Content of flavonoids in leaves of parsley (mean for 2009–2010) (mg·100 g^{-1})
Tabela 7. Zawartość flawonoidów w liściach pietruszki (średnio za lata 2009–2010) (mg·100 g^{-1})

Cultivar Odmiana	Fresh leaves Liście świeże			Frozen leaves Liście mrożone			Dry leaves Liście suche		
	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia	term of harvest termin zbioru		mean średnia
	August sierpień	September wrzesień		August sierpień	September wrzesień		August sierpień	September wrzesień	
'Amphia'	120a	70a	90a	180a	120a	150a	200a	230a	220a
'Festival'	40c	10c	30d	30b	80b	60b	90b	110b	200a
'Verta'	50b	30b	40c	50b	20c	40b	90b	0.06c	80c
Mean Średnia	70a	40b	60	90a	70a	80	0.13a	130a	170

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opinion that the content of vitamins (vitamin C in particular) is the indicator of the quality and appropriate usage of technological methods is established. Fresh parsley leaves include on average around 200 mg·100 g^{-1} of vitamin C in raw material [Pasikowska et al. 2002]. In this study the average content amounted to 185.62 mg·100 g^{-1} of raw material and it was influenced both by the term of harvest and the cultivar of parsley. There was slightly more vitamin C in the leaves harvested in September (194.87 mg·100 g^{-1}). In the leaves of the cultivar 'Festival' the highest amount was determined (291.00 mg·100 g^{-1}). The loses of vitamin C during the process of freezing were very high – reaching even 90%. Similar results were achieved by Lisiewska and Kmiecik [1997]. Several research works have been presented in the literature about the application of air-drying for parsley leaves [Berset and Caniaux 1983, Doymaz et al. 2006]. They are related to influence of drying processes on nutritional and sensory quality such as flavour, aroma and colour of parsley leaves. In this study the process of drying had negative influence on the content of vitamin C in the leaves of all parsley varieties – in the dry material only traces of vitamin C were determined (tab. 4).

The results of this experiment show the significant influence of the term of harvest and the cultivar on the content of essential oil in the fresh leaves of parsley. The higher content of essential oil was determined in the leaves harvested in August (0.16%) (tab. 5). In the frozen material the content of essential oil depended on the cultivar, but there were no significant differences between the terms of harvest. Dried leaves proved to be different in the content of the this biologically active compound. In case of cultivar 'Festival' and 'Verta' dry leaves had similar quantity of essential oil to the fresh leaves.

The results of this study showed the significant influence of the term of harvest and the cultivar on the content of polyphenolic acids in fresh leaves of parsley. The leaves harvested in August had significantly higher content of polyphenolic acids (100 mg·100 g^{-1}) in comparison to the leaves harvested in September (11 mg·100 g^{-1}) (tab. 6). It does not confirm the results gained by Gajc-Wolska et al. [2006], which showed the higher concentration of these compounds in the parsley leaves harvested in September. There was significantly highest amount of polyphenolic acids in the leaves of cultivars 'Verta' and 'Festival' (70 mg·100 g^{-1} and 60 mg·100 g^{-1}) than in cultivar 'Amphia' (37 mg·100 g^{-1}).

All factors of the experiments significantly influenced the content of flavonoids in fresh, frozen and dried leaves of parsley (tab. 7). The higher content of flavonoids was determined in parsley leaves harvested in August term (70 mg·100 g^{-1}). Among the compared cultivars in the leaves of 'Amphia' the highest content of flavonoids was determined (90 mg·100 g^{-1}). Drying process had more positive effect on quantity of flavonoids then freezing.

CONCLUSIONS

1. The yield of leaf parsley depended significantly on the term of harvest and the cultivar. The best yielding was the cultivar 'Amphia' (2.61 kg·m^{-2}), followed by 'Festival' (2.11 kg·m^{-2})

2. The content of biologically active compounds in the leaves of parsley depended on the term of leaves harvest, the cultivar and the used conservation method:

a. the content of determined groups of active compounds (except vitamin C) is higher in the raw material collected in the first time of harvest (in August), compared with the second one (September);

b. cultivar 'Amphia' is characterized by a higher content of carotenoids and flavonoids in comparison with the cultivars 'Festival' and 'Verta', the cultivar 'Verta' contains more chlorophyll and polyphenolic acids, and cultivar 'Festival' – more vitamin C;

c. cultivars 'Festival' and 'Verta' do not differ in content of essential oil;

d. the content of assimilate pigments and vitamin C in leaves of parsley clearly falls under the influence of freezing and drying (in the case of vitamin C drying completely degrades the vitamin);

e. freezing reduces the essential oil content and polyphenolic acids in the leaves of parsley, drying increases the content of these components in the case of flavonoids, both conservation methods increase their content in the analyzed raw material.

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OCENA JAKOŚCI WYBRANYCH ODMIAN PIETRUSZKI NACIOWEJ (*Petroselinum sativum* L. ssp. *crispum*)

Streszczenie. Ze względu na walory biologiczne liście pietruszki naciowej są cenionym warzywem jako bogate źródło soli mineralnych oraz jedno z najbogatszych źródeł witaminy C i β-karotenu. Celem przeprowadzonych badań była ocena plonowania i jakości liści trzech odmian pietruszki naciowej: 'Amphia', Festival' i 'Verta'. W doświadczeniu przeprowadzonym w latach 2009–2010 określono plon liści z jednostki powierzchni oraz wpływ metody konserwacji (mrożenie, suszenie) na zawartości w nich substancji czynnych. Surowiec (liście) zbierano dwukrotnie: w drugiej dekadzie sierpnia i września. We wszystkich rodzajach surowca określono zawartość olejku eterycznego, flawonoidów, kwasów polifenolowych, witaminy C, karotenoidów oraz chlorofilu. Plon liści z 1 m^{-2} wynosił średnio od 0,55 kg do 3.57 kg. Wyższą masę liści uzyskano podczas drugiego terminu zbioru surowca w przypadku wszystkich ocenianych odmian. Najplenniejszą odmianą okazała się odmiana 'Amphia' (2,61 kg·m^{-2}). Zawartość związków biologicznie

czynnych w liściach pietruszki naciowej istotnie zależała od odmiany, terminu ich zbioru i metody konserwacji. Zawartość barwników asymilacyjnych i witaminy C w liściach pietruszki wyraźnie spadła pod wpływem mrożenia i suszenia (w przypadku witaminy C suszenie całkowicie rozkładało tę witaminę). Mrożenie obniżało zawartość olejku eterycznego i kwasów polifenolowych w liściach pietruszki, natomiast suszenie termiczne wpływało na wzrost zawartości tych składników.

Słowa kluczowe: pietruszka naciowa, plonowanie, metody stabilizacji, olejek eteryczny, flawonoidy, kwasy polifenolowe

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