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COMPARISON OF BASIC CHEMICAL AND MINERAL COMPOSITION IN EDIBLE PARTS OF CHOSEN PEAR CULTIVARS PRODUCED IN PODKARPACKIE PROVINCE

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Abstract. Pears, besides apples, are also popular fruit species at the Polish fruit market. It is connected not only with their delicious taste but, among others, year-round availability at the market. The research objective was to determine and compare the basic chemical composition, i.e. dry matter, N-compounds (total), mineral elements (total), dietary fiber and easily hydrolyzed sugars (NFE), vitamin C as well as mineral content of: Mg, K, Na, Ca, Mn and Fe in the flesh and the peel of pears of the following cultivars: 'Bonkreta Willimsa', 'Concorde', 'General Leclerc', 'Faworytka', 'Komisówka', 'Konferencja' and 'Lukasówka' harvested in 2009 and 2010. In all the analyzed pear cultivars, nutrient concentration appeared to be higher in the fruit peel compared to the flesh. The pears from the 'Concorde'cv (average 23% f.m. –dry matter, 0.5% f.m. – N-compounds, 19.1% f.m. – NFE) and 'Lukasówka' cv. (average 23.1% f.m. – dry matter., 0.5% f.m. – N-compounds, 19.2% f.m. – NEF). The highest fiber content was determinated in friuts 'Faworytka' (average peel – 7.2% f.m., flesh – 0.7% f.m..).Whereas the highest concentration of vitamin C was observed in the peel and flesh of 'Concorde' (8.0–7.8 mg 100^{-1} f.m.), 'Faworytka' (7.6–7.4 mg 100^{-1} f.m.) and 'Lukasówka' (8.4–8.0 mg 100^{-1} f.m.). While considering a mineral compound concentration, the richest were 'Concorde' cultivar pears (peel – 0.4% f.m.; flesh – 0. % f.m.). Out of the studied pear cultivars the lowest concentration of these elements was established in the 'Conference' and 'Komisówka' cultivars. There was determined the highest content of K in fruits of 'Bonkreta Williamsa', 'Concorde', 'Komisówka and 'Konferencja, Na – 'Faworytka' and 'Lukasówka, Ca – 'Concord' and 'Konferencja', Mg – 'Komisówka', Mn – 'Bonkreta Williamsa' and 'Concorde' and Fe – 'Concorde'. In most investigated pears, there was noted a higher concentrations of nutrients in fruit produced in 2009 year compared to 2010.

Key words: basic nutrients, chemical composition of fruit peel and flesh, *Pyrus communis* L.

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INTRODUCTION

The pear tree (*Pyrus communis* L.) has not yet reached a dominant role in the Polish fruit-growing industry [Tomczak 1991, Arogyaswamy and Koziol 2005, Zydlik 2007]. Although currently, this fruit tree area does not exceed 3% of the total fruit-growing area, pears, besides apples, are also popular fruit species at the Polish fruit market [Babicz-Zielinska 1999, Konopacka et al. 2010]. It is connected not only with their delicious taste but, among others, year-round availability at the market and a wide range of varieties to satisfy full spectrum of preferences as well [Chervin et al. 2000, Ismail et al. 2001, Pedreschi et al. 2008].

Fruits have become a vital part of an every day diet of Poles [Adamczyk 2002, Szczepaniak et al. 2004]. It is associated with the increasing awareness and knowledge of consumers on beneficial health consequences of vitamins, mineral compounds and other biologically active substances that fruits contain. [Fulker 2001, Mirmiran et al. 2009, Stelmach et al. 2005].

The aim of the present study was to determine and compare the basic chemical composition, that is dry matter, mineral elements (total), N-compounds (total), dietary fiber, easily hydrolyzed sugars (NFE) and vitamin C as well as Mg, K, Na, Ca, Mn, Fe content in the fruit flesh and skin. The research included the 'Bonkreta Williamsa', 'Concorde', 'General Leclerc', 'Faworytka', 'Komisówka', 'Konferencja' and 'Lukasówka' cultivars pears harvested in 2009–2010.

MATERIAL AND METHODS

The material for researchs was harvested in dates: 11–15.09 ('Bonkreta Wilimsa'), 22.09–25.09. ('Concorde', 'Komisówka'), 25.09–28.09 ('General Leclerc', 'Komisówka', 'Lukasówka'), 25–28.08 ('Faworytka") 2009 and 2010, the time of fruit storage maturity. Harvest date were determined on the grounds of pear evaluation, that is, degree of peel coloration, flesh firmness and starch index [Jager et al. 1996]. The average yield of fruit from a tree amounted to 16.6 kg (2009) and 15.9 kg (2010). The size of pears harvested in the years 2009 and 2010 was comparable and averaged 190–200 g ('Bonkreta Williamsa', 'Concorde'), 200–220 g ('General Leclerc', 'Lukasówka'), 180–200 g ('Faworytka', 'Komisówka') and 160–180 g ('Konferencja').

The temperature in 2009 was recorded from 9.3°C (April) and 10.9°C (May) and 9.41°C (June) and 14.7°C (July) and 19.4°C (September) to 20.1°C (Oktober) and from 12.6°C (April) and 17.6°C (May) and 21.2°C (June) and 23.6°C (July) and 22.85°C (September) to 15.8 (Oktober) in 2010. Long-term average (1951–2003) of monthly temperature was 7.4°C, 13.0°C, 16.2°C, 18.1°C , 13.5°C and 8.3°C respectively at that time. In vegetation period the volume of rainfall in 2009 was similar to that of long-term average. The year 2010 was much more wet. In the months May, June and July were recorded up to 3 times more rainfall compared to long-term average [WIOŚ Rzeszów 2011].

Fruits for chemical analyses were harvested in a productive orchard located close to the city Łańcut in the Podkarpackie Province. The pear trees were supplied with

80 kg N ha^{-1} in the urea form incorporated into the soil below surface before the blooming time. After the determination of some other mineral compounds in pear tree foliage and soil, no further mineral fertilization was performed. The orchard protection was managed according to The Orchard Protection Agenda (pear tree).

The laboratory studies included the following pear cultivars: 'Bonkreta Williamsa', 'General Leclerc', 'Faworytka', 'Komisówka', 'Konferencja' and 'Lukasówka'. Pears of each cultivar were randomly collected from 3–4 trees in three replications. At each replication, from each tree, there were harvested approximately 5 kg of fruits. Prior to the chemical analyses, the pears were kept in the cold storage (3–4°C), but not longer then 2 weeks. The samples of pears flesh and peels were taken with a special knife which allowed for sampling research material of the same thickness from all the peeled fruits.

The obtained specimens were examined for determination of basic chemical composition in compliance with standard procedures AOAC [2000]: dry matter (method 985.14), mineral total (method 920.153), N-compounds (method 928.08), readily hydrolyzed sugars (calculated on the full basic chemical composition) – whole group of simple carbohydrates and structural readily hydrolysable determinated in the nitrogen-free extract fraction (NFE) [Dz.U. nr 271, poz. 2688 2004], L-ascorbic acid – using enzymatic test kit.(Nr.10 409 677 035 – test – combination for 21 determinations), Boehringer Mannheim/r-Biopharm [Henniger 1981, Czerwiecki and Wilczyńska, 1999].

The research material prepared in this mode was incinerated in microwave muffle furnace and the resulting ash was dissolved in appropriate volume of 5ml 6 N HCl followed by 0. 10. and 100. dilution procedure. Then, a level of Mg, K, Na, Ca, Mn, Fe were determined using flameless atomic absorption spectrometry method with Spectr AA 880 instrument, Varian with atomization in graphite furnace and Zeeman background correction system at 309,3 nm wavelength,10 mA current intensity lamp and 0.5 nm fissure, at neutral gas (argon) flow rate – 3 l/min and pyrocoated graphite cuvettes [Chakraborty et al. 1996, Bermejo-Barrera et al. 2000].

The research results were analyzed statistically. The software package StatSoft STATISTICA 5.1.M was applied to determine the measures of location (mean, standard deviation, bottom and upper quartile, modal) as well as to establish the differences between the means by Duncan`s multiple range test (ANOVA variance analysis).

RESULTS AND DISCUSSION

The present researches showed varied concentration of nutrients in different pear cultivars. Therefore, a health-conscious consumer with broad knowledge on nutritional quality of each pear variety can make informed choices so he can select healthier fruits. Nevertheless, as the literature reports, most consumers still buy fruits on the basis of the visual quality factors, like shape, color etc [Ismail et al. 2001].

The present study revealed that the most valuable pears in relation to nutrient concentration in both, the peel and flesh proved to be the 'Concorde' (peel – 27.4% f.m., flesh – 18.5% f.m.) and 'Lukasówka' (peel – 27.7% f.m., flesh – 18,5% f.m.) cultivars (tab. 1 and 2). They are characterized by rather firm hard flesh and medium juiciness.

Table 1. The chemical composition of peel's pears chosen cultivars (% fresh matter)
Tabela 1. Skład chemiczny skórki wybranych odmian gruszek (% masy naturalnej)

Cultivar Odmiana	Williams Bonkreta Williamsa		Concorde		General Leclerc		Clapp's Favorite Faworytka		Doyenne du Comice Komisówka		Conference Konferencja		Beurre Alexander Lucas Lukasówka	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Number of samples Liczba prób	8	9	8	10	11	9	7	9	12	9	10	14	8	10
Dry matter – Sucha masa	22.5 Ns	23.0 Ns	27.3 Ns	27.6 Ns	23.3 Ns	23.6 Ns	26.6 Ns	27.0 Ns	23.3 Ns	23.4 Ns	24.9 Ns	24.9 Ns	27.8 Ns	27.8 Ns
SD (±)	0.49	0.24	1.40	0.16	0.56	0.46	0.55	0.36	0.44	0.55	0.57	0.12	0.31	0.19
Mean – Średnia	22.7 b		27.4 a		23.4 b		26.8 a		23.3 b		24.9 ab		27.7 a	
Bottom quartile – Kwartyl dolny	21.9		26.9		22.7		26.4		23.2		24.2		26.9	
Upper quartile – Kwartyl górny	23.4		27.9		23.9		27.6		23.8		25.6		27.9	
modal – Mediana	23.0		27.5		23.5		26.9		23.4		24.9		27.8	
Mineral elements – total Związki mineralne – ogółem	0.3 Ns	0.3 Ns	0.4 Ns	0.4 Ns	0.3 Ns	0.3 Ns	0.4 Ns	0.4Ns	0.3 B	0.4 A	0.3 Ns	0.4 Ns	0.3 A	0.2 B
SD(±)	0.03	0.06	0.05	0.09	0.04	0.04	0.42	0.09	0.04	0.11	0.05	0.06	0.02	0.08
Means – Średnia	0.3 b		0.4 a		0.3 b		0.4 a		0.4 a		0.3 b		0.3 b	
Bottom quartile – Kwartyl dolny	0.3		0.4		0.3		0.3		0.3		0.3		0.2	
Upper quartile – Kwartyl górny	0.3		0.5		0.4		0.4		0.4		0.4		0.3	
Modal – Mediana	0.3		0.4		0.3		0.4		0.4		0.4		0.3	
N – compounds – total Związki azotowe – ogółem	0.7 Ns	0.7 Ns	0.7 Ns	0.7 Ns	0.8 Ns	0.9 Ns	0.9 Ns	1.0 Ns	1.1 Ns	1.1 Ns	0.8 Ns	0.7 Ns	0.6 Ns	0.6 Ns
SD (±)	0.04	0.08	0.05	0.06	0.06	0.06	0.04	0.11	0.22	0.12	0.06	0.08	0.04	0.07
Mean – Średnia	0.7 d		0.7 d		0.9 b		0.9 b		1.1 a		0.8 c		0.7 d	
Bottom quartile – Kwartyl dolny	0.7		0.7		0.8		0.9		1.0		0.7		0.6	
Upper quartile – Kwartyl górny	0.8		0.8		0.9		1.0		1.2		0.8		0.7	
Modal – Mediana	0.8		0.8		0.9		1.0		1.1		0.8		0.6	

Fiber – Błonnik	4.88 A	4.95 A	5.0 Ns	5.1 Ns	4.3 Na	4.3 Ns	7.1 Ns	7.3 Ns	6.9 Ns	7.0 Ns	5.5 Ns	5.7 Ns	5.0 Ns	5.1 Ns
SD (±)	0.16	0.15	0.12	0.24	0.23	0.14	0.43	0.34	0.29	0.15	0.33	0.21	0.24	0.26
Mean – Średnia	4.9 c		5.1 bc		4.3 c		7.2 a		6.9 a		5.6 b		5.0 bc	
Bottom quartile – Kwartyl dolny	4.8		4.9		4.2		7.0		6.7		5.3		4.8	
Upper quartile – Kwartyl górny	5.0		5.2		4.4		7.5		7.2		5.7		5.1	
Modal – Mediana	4.9		5.0		4.3		7.3		7.0		5.6		5.0	
Readily hydrolyzed sugars Cukry łatwo hydrolizujące	16.2 Ns	16.6 Ns	20.7 Ns	20.8 Ns	17.5 Ns	17.8 Ns	18.0 Ns	18.1 Ns	14.7 Ns	14.5 Ns	17.9 Ns	17.7 Ns	21.4 Ns	21.3 Ns
SD (±)	0.46	0.16	0.19	0.19	0.81	0.38	0.63	0.87	0.42	0.58	0.54	0.31	0.50	0.49
Mean – Średnia	16.4 c		20.8 a		17.7 bc		18.1 b		14.6 d		17.8 bc		21.2 a	
Bottom quartile – Kwartyl dolny	15.8		20.2		16.4		18.0		14.2		17.6		20.9	
Upper quartile – Kwartyl górny	16.8		21.1		18.0		18.3		15.0		17.8		21.9	
Modal – Mediana	16.3		20.9		17.7		18.2		14.8		17.7		21.4	
Vit. C – Wit. C (mg 100 g^{-1}f.m.)	5.1 Ns	5.1 Ns	8.1 Ns	8.0 Ns	6.8 Ns	7.0 Ns	7.5 Ns	7.6 Ns	6.0 Ns	6.2 Ns	6.4 Ns	6.3 Ns	8.3 Ns	8.4 Ns
SD (±)	0.23	0.16	0.43	0.36	0.12	0.15	0.33	0.19	0.09	0.29	0.09	0.17	0.12	0.09
Mean – Średnia	5.1 c		8.0 a		6.9 ab		7.6 a		6.1 b		6.3 b		8.4 a	
Bottom quartile – Kwartyl dolny	5.0		8.0		6.6		7.2		6.0		6.1		8.1	
Upper quartile – Kwartyl górny	5.2		8.1		7.1		8.0		6.4		6.8		8.7	
Modal – Mediana	5.1		9.0		7.1		7.6		6.2		6.4		8.4	

A, B, C,… – significant differences between the content of chemical elements in pears the same cultivar in 2009 and 2010 years $p \leq 0.05$ – różnice statystycznie istotne pomiędzy średnią zawartością składników chemicznych gruszek tej samej odmiany w latach 2009–2010 dla $p \leq 0,05$

Ns – not significant differences – różnice nieistotne statystycznie

a, b, c,… – significant differences between the average content of chemical elements in pears different cultivars $p \leq 0.05$ – różnice statystycznie istotne pomiędzy średnią zawartością składników chemicznych gruszek różnych odmian dla $p \leq 0,05$

SD – standard deviation – odchylenie standardowe; quartile (upper, bottom); modal – positional averages (averages measures) – kwartyle (górny, dolny); mediana – miary położenia (miary średnie)

Table 2. The chemical composition of flesh's pears chosen cultivars (% fresh matter)
Tabela 2. Skład chemiczny miąższu wybranych odmian gruszek (% masy naturalnej)

Cultivar Odmiana	Williams Bonkreta Williamsa		Concorde		General Leclerc		Clapp's Favorite Faworytka		Doyenne du Comice Komisówka		Conference Konferencja		Beurre Alexander Lucas Lukasówka	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Number of samples Liczba prób	8	9	8	10	11	9	7	9	12	9	10	14	8	10
Dry matter – Sucha masa	18.1 Ns	18.3 Ns	18.5 Ns	18.6 Ns	17.3 Ns	17.3 Ns	17.3 Ns	17.4 Ns	13.7 Ns	13.3 Ns	16.0 Ns	15.9 Ns	18.4 Ns	18.6 Ns
SD (±)	0.20	0.12	0.31	0.18	0.62	0.38	0.16	0.48	0.19	0.08	0.19	0.24	0.46	0.14
Mean – Średnia	18.2 a		18.5 a		17.3 ab		17.4 ab		13.5 c		15.9 b		18.5 a	
Bottom quartile – Kwartyl dolny	18.0		18.2		16.8		17.2		13.3		15.8		18.0	
Upper quartile – Kwartyl górny	18.3		18.8		17.3		17.5		13.5		16.1		18.9	
Modal – Mediana	18.3		18.7		17.2		17.4		13.3		16.0		18.4	
Mineral elements – total Związki mineraln – ogółem	0.3 Ns	0.3 Ns	0.3 Ns	0.4 Ns	0.2 Ns	0.2 Ns	0.3 Ns	0.3 Ns	0.2 Ns	0.2 Ns	0.3 Ns	0.3 Ns	0.3 Ns	0.3 Ns
SD(±)	0.10	0.12	0.04	0.11	0.01	0.28	0.02	0.19	0.03	0.12	0.02	0.09	0.03	0.07
Mean – Średnia	0.3 a		0.3 a		0.2 b		0.3 a		0.2 b		0.3 a		0.3 a	
Bottom quartile – Kwartyl dolny	0.2		0.3		0.2		0.3		0.2		0.3		0.3	
Upper quartile – Kwartyl górny	0.3		0.4		0.2		0.3		0.3		0.3		0.4	
Modal – Mediana	0.3		0.3		0.2		0.3		0.2		0.3		0.3	
N – compounds – total Związki azotowe – ogółem	0.3 Ns	0.3 Ns	0.2 Ns	0.2 Ns	0.2 Ns	0.3 Ns	0.3 Ns	0.3 Ns	0.2 Ns	0.2 Ns	0.3 Ns	0.4 Ns	0.3 Ns	0.3 Ns
SD (±)	0.02	0.16	0.03	0.09	0.03	0.19	0.02	0.09	0.05	0.1	0.03	0.17	0.07	0.27
Mean – Średnia	0.3 a		0.2 b		0.3 a		0.3 a		0.2 b		0.3 a		0.3 a	
Bottom quartile – Kwartyl dolny	0.3		0.2		0.2		0.3		0.2		0.3		0.2	
Upper quartile – Kwartyl górny	0.3		0.3		0.3		0.3		0.2		0.4		0.4	
Modal – Mediana	0.3		0.2		0.2		0.3		0.2		0.4		0.3	

Fiber – Błonnik	0.7 Ns	0.7 Ns	0.4 Ns	0.4 Ns	0.3 Ns	0.3 Ns	0.7 B	0.8 A	0.4 A	0.3 B	0.7 Ns	0.6 Ns	0.6 Ns	0.6 Ns
SD (±)	0.12	0.15	0.06	0.05	0.12	0.23	0.09	0.18	0.11	0.09	0.16	0.36	0.23	0.13
Mean – Średnia	0.7 a		0.4 c		0.3 d		0.7 a		0.4 c		0.6 b		0.6 b	
Bottom quartile – Kwartyl dolny	0.6		0.4		0.3		0.7		0.3		0.6		0.6	
Upper quartile – Kwartyl górny	0.7		0.5		0.3		0.8		0.5		0.7		0.7	
Modal – Mediana	0.7		0.5		0.3		0.8		0.4		0.7		0.6	
Readily hydrolyzed sugars Cukry łatwo hydrolizujące	15.3 B	16.9 A	17.4 Ns	17.4 Ns	16.5 Ns	16.5 Ns	16.0 Ns	15.8 Ns	12.4 Ns	12.5 Ns	14.6 Ns	14.5 Ns	17.2 Ns	17.3 Ns
SD (±)	0.14	0.13	0.32	0.09	0.63	0.23	0.16	0.16	0.14	0.13	0.15	0.23	0.65	0.36
Mean – Średnia	16.1 ab		17.4 a		16.5 ab		15.9 ab		12.4 c		14.6 b		17.2 a	
Bottom quartile – Kwartyl dolny	14.6		17.3		16.0		15.9		12.4		14.5		16.6	
Upper quartile – Kwartyl górny	17.1		17.7		17.4		16.1		12.5		14.7		17.6	
Modal – Mediana	15.9		17.5		16.4		16.0		12.4		14.6		16.9	
Vit. C –Wit. C (mg 100 g^{-1}f.m.)	5.0 Ns	5.0 Ns	7.7 Ns	8.0 Ns	6.8 Ns	6.8 Ns	7.1 Ns	7.6 Ns	6.1 B	8.1 A	6.3 B	9.2 A	7.9 A	8.0 A
SD (±)	0.12	0.26	0.23	0.37	0.09	0.13	0.09	0.12	0.16	0.24	0.20	0.36	0.36	0.24
Mean – Średnia	5.0 c		7.8 a		6.8 b		7.4 ab		7.1 ab		7.7 a		8.0 a	
Bottom quartile – Kwartyl dolny	4.9		7.2		6.4		7.1		6.0		6.1		7.7	
Upper quartile – Kwartyl górny	5.1		8.0		7.0		7.6		6.4		9.4		8.1	
Modal – Mediana	4.9		7.8		6.9		7.4		6.1		7.5		8.0	

A, B, C,.… – significant differences between the content of chemical elements in pears the same cultivar in 2009 and 2010 years $p \leq 0.05$ – różnice statystycznie istotne pomiędzy średnią zawartością składników chemicznych gruszek tej samej odmiany w latach 2009–2010 dla $p \leq 0,05$

Ns – not significant differences – różnice nieistotne statystycznie

a, b, c,… – significant differences between the average content of chemical elements in pears different cultivars $p \leq 0.05$ – różnice statystycznie istotne pomiędzy średnią zawartością składników chemicznych gruszek różnych odmian dla $p \leq 0,05$

SD – standard deviation – odchylenie standardowe; quartile (upper, bottom); modal – positional averages (averages measures) – kwartyle (górny, dolny); mediana – miary położenia (miary średnie)

The significant lowest dry matter content was determined for 'Komisówka' (peel – 23.3% f.m.; flesh – 13.5% f.m.) cultivar pears are among the sweetest and juiciest pears, probably owing to a relatively high water content. Similar dry matter concentration was determined in different pear varieties by Guiné and Castro [2002, 2003] while preparing the fruits for the drying process

In all the pear cultivars, there was established a higher dry matter content in the peel as compared to the flesh. That results from the pear peel function, namely structural as well as protective against the outer conditions [Guiné 2006]. High nutrient concentration in the peel confirms the dietary recommendations to consume whole fruits as the peels on pears are rich sources of valuable nutrients [Fulker 2001].

The present investigations displayed that 'Concorde' cultivar fruits had the significant highest mineral elements (total) concentration (peel – 0.3% f.m., flesh – 0.4% f.m.) (tab. 1 and 2). Similar content of these chemical compounds was also reported by Leontowicz et al. [2002] analyzing the fruits incorporated into rats' diet. Whereas, Barroca [2006] studying the Portuguese pear varieties observed a 2–3 fold higher concentration of minerals.

Pears, similarly to other fruits, are characterized by a very low level of N-compounds (total) (up to 1% f.m.) (tab. 1 and 2). Nitrogen compounds content in whole fruits at the 0.5% f.m. level was noted by Senser et al. [1999] and Silos-Espino et al. [2003]. The pear cultivars grown in the Mediterranean climate were found to contain nitrogen compounds ranging from 1.5 up to 2.06% dry matter [Barocca 2006]. The N concentration in fruits relies upon available soil nitrogen and reflects plant ability to N accumulation [Cheng et al. 2001, Neto et al. 2008].

The pears under study showed a differentiated dietary fiber content (tab. 1 and 2). Its components make up the principal structure material of plant cell walls including among others, cellulose, hemicellulose, pectins, lignins [DeVries and Faubion 1999, Nawirska and Kwaśniewska 2005]. Therefore, concentration of these compounds in the peel of the investigated fruits was even 10-fold higher than in the flesh. The presence of chemical substances included into the dietary fiber fraction in a diet is essential for proper digestion of nutrients and human gastrointestinal tract function and prevention against many lifestyle diseases development (colorectal cancers, cholesterol lowering effect, heart diseases, atherosclerosis) [Mirmiran et al. 2009, Connors et al. 2010]. The significantly highest fiber content were determined in pears of 'Faworytka', 'Komisówka' and 'Confrence' cultivars (average peel – 6.9% f.m, flesh – 0.7% f.m.).

Equally high differentiation was observed in the concentration of readily hydrolyzed sugars (tab. 1 and 2). During the fruit maturity time, complex sugars are progressively broken down to the simple sugars, primarily fructose that adds more taste and appealing flavor to fruits. Among the pears under study, the 'Concorde' and 'Lukasówka' cultivars proved to be most available in this sugar fraction (respectively peel – 20.8 and 21.2% f.m., flesh – 17.4 and 17.2% f.m.).

Comparison of the present research results (fiber and sugars) and those previously reported in the literature highlights some discrepancies [Ramulu and Rao 2003, Nawirska and Kwaśniewska 2005, Barroca 2006; Chen et al. 2007]. The difference in values can be associated with a variety, sample preparation or even a different methodology employed for the dietary fiber and sugars measurement.

The significantly highest vitamin C content in the studied material was determined in the pears of the 'Concorde', 'Faworytka' and 'Lukasówka' cultivars (the range of 8.4–7.6 mg 100^{-1} g f.m. peel and 7.9–7.4 mg 100^{-1} g f.m. – flesh) (tab. 1 and 2). Whereas, the significantly lowest vitamin C level was noted in the 'Bonkreta Williamsa' pears (average 5.0 mg 100^{-1} g f.m.). Alike, Veltman et al. [2000], Zerbini et al. [2002] and Franck et al. [2003] found similar amounts of this vitamin in pears of the 'Rocha' and 'Conference' cv. However, Chen et al. [2007] determined a vitamin C content at very varying level in pears grown in China.

In most cases, there was observed a tendency for accumulation of higher quantity of chemical compounds in the pears harvested in 2009 than in 2010, what probably was due to weather conditions. Although temperatures in 2009 were much lower than in 2010, but this year was characterized by the optimal and uniform distribution of rainfall, especially during fruit ripening. The statistically significant differences in chemical element concentration were established only in the 'Komisówka' and 'Lukasówka' pear cultivars (peel – mineral elements –total); 'Faworytka' and 'Komisówka' cv. (flesh – fiber); 'Bonkreta Williamsa` cv. (flesh – readily hydrolyzed sugars and vitamin C).

Mineral elements that are naturally found in fruits and vegetables are extremely important elements in the human body.

In most cases, there was observed higher concentration of mineral elements in the fruit skin than in the flesh (tab. 3 and 4).

The significant highest potassium content in both, the fruit peel and the flesh was determined in the 'Bonkreta Williamsa', 'Concorde', 'Komisówka' and 'Konferencja' cultivars pears (average and 126,38 mg g^{-1} f.m. in the peel, 112.8 mg g^{-1} f.m. in the flesh). While, the 'Lukasówka' cultivar pears appeared to be the least available in potassium, their flesh and peel were found to contain significantly lower by 15% K amount as compared to the highest values established.

The significantly highest sodium content was determined in the peel of the 'General Leclerc' and 'Faworytka' pears (average 2.0 mg g^{-1} f.m.) and in the flesh of the 'Concorde', 'Faworytka' and 'Lukasówka' cultivars (average1.99 mg g^{-1} f.m.), whereas the lowest sodium level, even by 50%, was detected in the flesh and peel of the 'Conference' cultivars fruits.

The present study showed the significant highest calcium content in the flesh and peel of the 'Concorde' and 'Konferencja' cultivars pears (average 13.1 mg g^{-1} f.m. in the flesh and 16.2 mg g^{-1} f.m. in the peel). Whereas in the 'Komisówka' and 'Lukasówkas' pears the calcium accumulation was lower by 22% in the peel and 20%.

The significant highest magnesium level in the studied fruits was noted in the 'Bonkreta Williamsa', 'Concorde', 'Komisówka' and 'Likasówka' cultivars pears (average 12.8 mg g^{-1} f.m. in the peel and 10.8 mg g^{-1} f.m. in the flesh). In the cultivars, this essential mineral content averaged 9.9 mg g^{-1} f.m. in the peel and the flesh.

Among the determined macro-element concentration, a manganese level was ranged between 96.6 ('Bonkreta Williamsa') and 73.0 mg g^{-1} f.m ('Lukasówka') average in the peel and in the flesh.

In all the skins of the varieties under study, there was established a significantly higher iron content as compared to the flesh and the differences were as much as 50%

Table 3. The content of K, Na, Ca, Mg, Mn and Fe in peel's pears chosen cultivars
Tabela 3. Zawartość K, Na, Ca, Mg, Mn i Fe w skórce gruszek wybranych odmian

Cultivar Odmiana	Williams Bonkreta Williamsa		Concorde		General Leclerc		Clapp's Favorite Faworytka		Doyenne du Comice Komisówka		Conference Konferencja		Beurre Alexander Lucas Lukasówka	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Number of samples Liczba prób	8	9	8	10	11	9	7	9	12	9	10	14	8	10
K (mg g^{-1} f.m.)	121.5 Ns	125.6 Ns	122.3 Ns	119.3 Ns	101.5 Ns	102.2 Ns	102.7 Ns	102.0 Ns	125.1 Ns	129.3 Ns	132.8 Ns	135.2 Ns	106.6 Ns	105.3 Ns
SD (±)	0.40	0.12	0.43	0.09	0.35	0.24	0.13	0.36	0.34	0.26	0.45	0.15	0.45	0.57
Mean – Średnia	123.5 a		120.8 a		102.0 b		102.4 b		127.2 a		134.0 a		105.9 b	
Bottom quartile – Kwartyl dolny	120.9		118.9		100.8		101.0		123.2		131.9		105.1	
Upper quartile – Kwartyl górny	126.4		124.6		106.0		105.7		130.0		136.2		108.8	
Modal – Mediana	123.9		121.8		103.8		100.4		127.7		132.6		106.4	
Na (mg g^{-1} f.m.)	1.3 Ns	1.3 Ns	1.3 Ns	1.3 Ns	2.0 Ns	2.1 Ns	2.0 Ns	2.2 ns	1.3 A	1.1 B	1.05 A	1.07 A	2.04 A	2.09 A
SD(±)	0.03	0.05	0.12	0.10	0.07	0.23	0.21	0.18	0.18	0.26	0.23	0.19	0.20	0.16
Mean – Średnia	1.3 b		1.3 b		2.1 a		2.0 a		1.2 b		1.1 b		2.1 a	
Bottom quartile – Kwartyl dolny	1.3		1.3		1.9		2.0		1.0		1.0		2.0	
Upper quartile – Kwartyl górny	1.3		1.3		2.2		2.4		1.3		1.1		2.1	
Modal – Mediana	1.3		1.3		2.0		2.0		1.1		1.0		2.1	
Ca (mg g^{-1} f.m.)	14.4 Ns	14.4 Ns	16.0 Ns	16.0 Ns	13.7 Ns	13.5 Ns	14.0 Ns	14.2 Ns	13.0 Ns	12.9 Ns	16.3 Ns	16.6 Ns	12.8 Ns	12.7 Ns
SD (±)	0.37	0.26	0.31	0.36	0.23	0.09	0.46	0.18	0.24	0.27	0.39	0.38	0.37	0.1
Mean – Średnia	14.4 bc		16.0 a		13.6 bc		14.1 b		12.9 c		16.4 a		12.7 c	
Bottom quartile – Kwartyl dolny	14.0		15.9		13.5		13.7		12.3		15.9		12.0	
Upper quartile – Kwartyl górny	14.6		16.1		14.0		14.4		13.2		17.0		12.8	
Modal – Mediana	14.6		16.0		13.6		14.0		12.9		16.5		12.7	

Mg (mg g^{-1} f.m.)	12.5 Ns	12.6 Ns	13.6 Ns	13.7 Ns	9.3 Ns	9.6 Ns	10.6 Ns	10.5 Ns	13.0 Ns	13.1 Ns	10.0 Ns	10.1 Ns	12.1 Ns	12.0 Ns
SD (±)	0.307	0.193	0.83	0.38	0.28	0.19	0.34	0.30	0.65	0.35	0.46	0.30	0.50	0.29
Mean – Średnia	12.6 ab		13.7 a		9.4 c		10.6 bc		13.1 a		10.0 bc		12.1 ab	
Bottom quartile – Kwartyl dolny	12.3		13.5		9.0		10.4		12.6		9.8		11.9	
Upper quartile – Kwartyl górny	12.8		14.6		9.8		10.9		13.2		10.3		12.3	
Modal – Mediana	12.5		13.7		9.4		10.6		13.0		10.0		12.0	
Mn (μg g^{-1} f.m.)	97.5 Ns	99.0 Ns	96.2 Ns	96.0 Ns	87.6 Ns	88.3 Ns	88.5 Ns	88.5 Ns	85.2 Ns	87.3 Ns	85.1 Ns	85.1 Ns	74.5 Ns	75.7 Ns
SD (±)	0.76	0.19	0.57	0.48	0.75	0.17	0.34	0.47	0.43	0.19	0.53	0.29	0.23	0.18
Mean – Średnia	98.3 a		96.1 ab		87.9 b		88.5 b		86.3 b		85.1 b		75.1 c	
Bottom quartile – Kwartyl dolny	96.9		95.4		87.0		87.9		85.0		85.0		73.9	
Upper quartile – Kwartyl górny	99.1		96.9		88.2		89.5		88.5		85.3		75.8	
Modal – Mediana	98.3		96.4		87.6		88.3		86.4		85.1		75.0	
Fe (μg g^{-1} f.m.)	0.4 Ns	0.5 Ns	0.5 A	0.4 B	0.5 Ns	0.5 Ns	0.3 Ns	0.3 Ns	0.3 Ns	0.3 Ns	0.4 B	0.5 A	0.3 Ns	0.3 Ns
SD (±)	0.12	0.18	0.07	0.08	0.04	0.09	0.08	0.09	0.14	0.20	0.04	0.10	0.13	0.11
Mean – Średnia	0.5 a		0.4 b		0.5 a		0.3 c		0.3 c		0.4 b		0.3 c	
Bottom quartile – Kwartyl dolny	0.4		0.4		0.5		0.3		0.3		0.4		0.3	
Upper quartile – Kwartyl górny	0.5		0.5		0.6		0.3		0.4		0.5		0.3	
Modal – Mediana	0.4		0.5		0.5		0.3		0.4		0.4		0.3	

A, B, C,…. – significant differences between the content of chemical elements in pears the same cultivar in 2009 and 2010 years $p \leq 0.05$ – różnice statystycznie istotne pomiędzy średnią zawartością składników chemicznych gruszek tej samej odmiany w latach 2009–2010 dla $p \leq 0,05$

Ns – not significant differences – różnice nieistotne statystycznie

a, b, c,…. – significant differences between the average content of chemical elements in pears different cultivars $p \leq 0.05$ – różnice statystycznie istotne pomiędzy średnią zawartością składników chemicznych gruszek różnych odmian dla $p \leq 0,05$

SD – standard deviation – odchylenie standardowe; quartile (upper, bottom); modal – positional averages (averages measures) – kwartyle (górny, dolny); mediana – miary położenia (miary średnie)

Table 4. The content of K, Na, Ca, Mg, Mn and Fe in flesh's pears chosen cultivars
Tabela 4. Zawartość K, Na, Ca, Mg, Mn i Fe w miąższu gruszek wybranych odmian

Cultivar Odmiana	Williams Bonkreta Williamsa		Concorde		General Leclerc		Clapp's Favorite Faworytka		Doyenne du Comice Komisówka		Conference Konferencja		Beurre Alexander Lucas Lukasówka	
	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010	2009	2010
Number of samples Liczba prób	8	9	8	10	11	9	7	9	12	9	10	14	8	10
K (mg g^{-1} f.m.)	100.9 Ns	101.2 Ns	106.9 Ns	106.5 Ns	106.9 Ns	105.9 Ns	111.4 Ns	111.6 Ns	112.0 Ns	111.9 Ns	111.0 Ns	110.6 Ns	96.2 Ns	97.3 Ns
SD (±)	0.27	0.39	0.10	0.30	0.12	0.37	0.89	0.36	1.23	0.39	0.09	0.39	0.16	0.32
Mean – Średnia	101.0 ab		106.7 ab		106.4 ab		111.5 a		112.4 a		110.8 ab		96.8 b	
Bottom quartile – Kwartyl dolny	100.4		105.8		105.9		109.6		110.6		109.2		96.1	
Upper quartile – Kwartyl górny	102.0		106.7		107.2		113.1		112.9		112.6		97.5	
Modal – Mediana	101.2		106.9		106.6		111.6		112.6		111.1		96.6	
Na (mg g^{-1} f.m.)	1.3 Ns	1.3 Ns	2.0 Ns	2.1 Ns	1.3 A	1.1 B	2.0 A	1.8 B	1.8 A	1.3 B	1.1 Ns	1.1 Ns	2.0 Ns	1.9 ns
SD(±)	0.12	0.17	0.16	0.17	0.08	0.16	0.58	0.38	0.38	0.28	0.16	0.16	0.58	0.28
Mean – Średnia	1.3 bc		2.1 a		1.2 d		1.9 a		1.5 b		1.1 c		2.0 a	
Bottom quartile – Kwartyl dolny	1.3		2.0		1.0		1.		1.3		1.0		1.8	
Upper quartile – Kwartyl górny	1.4		2.2		1.4		2.1		1.8		1.2		2.1	
Modal – Mediana	1.3		2.3		1.2		1.8		1.5		1.1		2.1	
Ca (mg g^{-1} f.m.)	12.6 Ns	12.6 Ns	13.4 Ns	13.3 Ns	10.4 B	12.8 A	10.1 Ns	10.3 Ns	10.4 Ns	10.3 Ns	12.8 Ns	12.8 Ns	11.1 Ns	10.8 Ns
SD (±)	0.28	0.12	0.10	0.36	0.29	0.15	0.31	0.18	0.30	0.12	0.25	0.21	0.31	0.13
Mean – Średnia	12.6 ab		13.4 a		11.6 b		10.2 b		10.4 b		12.8 ab		10.9 b	
Bottom quartile – Kwartyl dolny	12.4		13.2		10.4		9.9		9.9		12.6		9.9	
Upper quartile – Kwartyl górny	12.8		13.9		13.0		10.3		10.7		13.0		11.3	
Modal – Mediana	12.6		13.4		11.5		10.2		10.3		12.9		10.8	

Mg (mg g^{-1} f.m.)	10.1 Ns	10.1 Ns	9.3 Ns	9.4 Ns	11.8 Ns	11.1 Ns	9.8 Ns	9.0 Ns	12.0 B	12.8 A	9.8 Ns	10.1 Ns	9.8 Ns	9.8 Ns
SD (±)	0.331	0.128	0.36	0.24	0.37	0.42	0.15	0.12	0.12	0.37	0.42	0.12	0.11	0.23
Mean – Średnia	10.1 b		9.4 b		11.5 ab		9.4 b		12.4 a		9.9 b		9.8 b	
Bottom quartile – Kwartyl dolny	9.89		9.2		11.0		8.9		12.2		9.5		9.6	
Upper quartile – Kwartyl górny	10.26		9.6		12.0		10.0		13.1		10.3		10.3	
Modal – Mediana	10.02		9.4		11.5		9.6		12.6		9.9		10.0	
Mn (μg g^{-1} f.m.)	94.3 Ns	95.8 Ns	88.3 Ns	88.6 Ns	87.4 Ns	88.3 Ns	71.2 Ns	71.6 Ns	87.4 Ns	88.0 Ns	88.3 Ns	89.0 Ns	71.2 Ns	70.8 Ns
SD (±)	0.26	0.13	0.35	0.24	0.26	0.36	0.25	0.14	0.26	0.10	0.36	0.24	0.25	0.13
Mean – Średnia	95.0 a		88.4 a		87.8 a		71.4 b		87.7 a		88.7 a		71.0 b	
Bottom quartile – Kwartyl dolny	94.0		86.8		87.2		71.2		86.9		88.0		70.9	
Upper quartile – Kwartyl górny	96.0		88.8		88.6		71.8		88.1		89.6		72.0	
Modal – Mediana	94.9		88.5		87.8		71.4		87.8		88.7		71.0	
Fe (μg g^{-1} f.m.)	0.2 Ns	0.3 Ns	0.3 Ns	0.3 Ns	0.2 B	0.3 A	0.2 B	0.3 A	0.3 A	0.2 B	0.2 Ns	0.2 Ns	0.21 B	0.3 A
SD (±)	0.12	0.28	0.14	0.08	0.02	0.25	0.12	0.07	0.17	0.22	0.13	0.19	0.12	0.06
Mean – Średnia	0.2 b		0.3 a		0.2 b		0.3 a		0.2 b		0.2 b		0.2 b	
Bottom quartile – Kwartyl dolny	0.2		0.2		0.2		0.2		0.2		0.2		0.2	
Upper quartile – Kwartyl górny	0.3		0.3		0.3		0.3		0.3		0.3		0.3	
Modal – Mediana	0.2		0.3		0.3		0.3		0.2		0.2		0.2	

A, B, C,….. – significant differences between the content of chemical elements in pears the same cultivar in 2009 and 2010 years $p \leq 0.05$ – różnice statystycznie istotne pomiędzy średnią zawartością składników chemicznych gruszek tej samej odmiany w latach 2009–2010 dla $p \leq 0,05$

Ns – not significant differences – różnice nieistotne statystycznie

a, b, c,…. – significant differences between the average content of chemical elements in pears different cultivars $p \leq 0.05$ – różnice statystycznie istotne pomiędzy średnią zawartością składników chemicznych gruszek różnych odmian dla $p \leq 0,05$

SD – standard deviation – odchylenie standardowe; quartile (upper, bottom); modal – positional averages (averages measures) – kwartyle (górny, dolny); mediana – miary położenia (miary średnie)

higher ('Bonkreta Williamsa', 'Concorde', 'General Leclerc' and 'Konferencja'). The pear cultivar found most abundant in this microelement proved to be 'General Leclerc'.

Importantly, the scatter of the data available in the literature addressing the problem of mineral content in pears should be highlighted. It may be attributed to large variability of a pear cultivar, climate variability, soil availability or the proper harvest time [Houdina and Štampar 1999, Silos-Espino et al. 2003, Wójcik and Wójcik 2003, Barroca et al. 2006, Cheng et al. 2001, Chen et al. 2007,]. A different level of mineral element accumulation in fruit is also affected by the rate of element accumulation in the whole plant and its parts. Buwaldaa and Meekingsa [1990] stated that, regardless of element soil availability, a Ca and Zn accumulation rate in pears proves to be directly proportional to time, while P, K, Mg, Fe and Mn, B accumulation is described better by the linear regression of the logarithm of the nutrient content with time. Besides, out of the total pool of microelements in soil, the highest quantity of P, K, Cu and B accumulated in fruits, Ca and Mn – in leaves, while S, Fe and Zn in a similar level in fruits and leaves [Fallahi and Larsen 1984, Marschner 1995, Souza et al. 2001, Thomidis et al. 2007].

The measures of location computed for each pear cultivars illustrate the distribution of value variation of the analyzed chemical element within the studied group.

CONCLUSIONS

There was noted higher concentration of nutrients and mineral elements in the peels of all the pear cultivars investigated as compared to the fruit flesh. Among the analyzed pears, the highest nutrient content in the dry matter was determined in the 'Concorde' and 'Lukasówka' cultivars. The largest amount of mineral elements (total) was detected in the fruits of the 'Concorde', 'Komisówka' and 'Konferencja' cultivars. Whereas N-compounds (total) concentration was found to be very low up to 1% f.m. The analysis of the carbohydrates compounds showed the highest content of dietary fiber in the 'Faworytka' cultivars pears and the lowest in 'General Leclerc'. As for easily hydrolyzed sugars, the most abundant proved to be the 'Concorde' and 'Lukasówka' cv. fruits.

The highest level of K was noted in the cv. 'Concorde', 'Komisówka' and 'Konferencja' cv., Na – in the 'General Leclerc', 'Faworytka' and 'Lukasówka' cv., Ca, – in the 'Concorde' cv., Mg – in the 'Concorde', 'Komisówka' and 'Lukasówka' cv., Mn – in the 'Bonkreta Williamsa' and 'Concorde' cv., Fe – in the 'Concorde', 'General Leclerc' and 'Konferencja' cv. pears.

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PORÓWNANIE PODSTAWOWEGO SKŁADU CHEMICZNEGO ORAZ MINERALNEGO W CZĘŚCIACH JADALNYCH WYBRANYCH ODMIAN GRUSZEK WYPRODUKOWANYCH W WOJEWÓDZTWIE PODKARPACKIM

Streszczenie. Gruszki, obok jabłek, cieszą się dużą popularnością, co związane jest nie tylko z ich wyjątkowo wysokimi walorami smakowymi, ale również m.in z całoroczną dostępnością na rynku. Celem pracy było określenie i porównanie podstawowego składu chemicznego: suchej masy, związków azotowych (ogółem), związków mineralnych (ogółem), błonnika pokarmowego, cukrów łatwo hydrolizujących (BAW) oraz witaminy C, a także zawartości związków mineralnych jak: Mg, K, Na, Ca, Mn i Fe w miąższu i skórce gruszek odmian: 'Bonkreta Williamsa', 'Concorde', 'General Leclerc', 'Faworytka', 'Komisówka', 'Konferencja' i 'Lukasówka' pochodzących ze zbiorów 2009 i 2010 r. We wszystkich badanych odmianach gruszek koncentracja składników pokarmowych i mineralnych była wyższa w skórce w porównaniu z miąższem. Najzasobniejszymi w suchą masę, związki azotowe i węglowodany przyswajalne, zarówno w skórce, jak i miąższu. okazały się gruszki odmian: 'Concorde'(średnio 23,0% m.n. – sucha masa, 0,5% m.n. – zw. N, 19,1% m.n. – BAW) i 'Lukasówka'(średnio 23,1% m.n. – sucha masa, 0,5% m.n. – zw. N, 19,2% m.n. – BAW). Największą zawartość włókna oznaczono w owocach 'Faworytki' (średnio skórka – 7,2% m.n., miąższ – 0,7% m.n.). Natomiast najwyższą zawartością witaminy C charakteryzował się miąższ i skórka gruszek 'Concorde' (8,0–7,8 mg 100^{-1} m.n.), 'Faworytka' (7,6–7,4 mg 100^{-1} m.n) i 'Lukasówka' (8,4–8,0 mg 100^{-1} m.n). Pod względem ogólnej koncentracji związków mineralnych, zdecydowanie najlepsze okazały się owoce odmiany 'Concorde' (skórka – 0,4% m.n; miąższ – 0,3% m.n.). Natomiast najmniej oznaczono ich w owocach 'Faworytki' i 'Konferencji'. Największe zawartości K oznaczono w owocach 'Bonkreta Williamsa', 'Concorde', 'Komisówka i 'Konferencja, Na – w 'Faworytka', 'Lukasówka, Ca – 'Concord' i 'Konferencja', Mg – 'Komisówka', Mn – 'Bonkreta Williama i 'Concorde' oraz Fe – 'Concorde'. W większości analizowanych gruszek stwierdzono wyższą koncentrację analizowanych składników odżywczych w owocach wyprodukowanych w 2010 r. w porównaniu z 2009 r.

Słowa kluczowe: podstawowe składniki odżywcze, skład chemiczny skórki i miąższu, *Pyrus communis* L.

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