ACTA Acta Sci. Pol., Hortorum Cultus 11(3) 2012, 3-14

COMPARATIVE STUDY ON MINERAL CONTENT OF ORGANIC AND CONVENTIONAL APPLE, PEAR AND BLACK CURRANT JUICES

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Abstract. The nutritional quality of food raised by organic farming in comparison to conventional farming is a currant topic that focuses interest and generate discussion. The data on nutritional quality of organic produce in comparison to conventional produce are often inconclusive. The study presents comparison of some nutritional values of juices made from organic and conventionally grown fruits (apple, pear, black currant). For the experiment 33 orchards located in the south and east of Poland were chosen. All organic farms were certified according to UE Council Regulation no. 2092/91 and obtained valid certificates. Unclarified juices were obtained with cold press juicer. After microwave mineralization in HNO_3 the following nutrient elements were measured: P, K, Mg, Ca, S, Fe, Zn, Mn, Cu, B as well as Na, Cd, Pb, and Ni. Moreover, ammonium N and nitrates content were evaluated using FIA method. Black currant juices contained the highest amounts of Ca, K, Mg, P, S, Fe, Mn and Na. In the case of Ca, Fe and Mn the measured levels were ten times higher than for other juices. The highest content of Cu was proved for pear, whereas apple juices revealed the highest B amount. The husbandry method also influenced the mineral content of the juices, however in different manner for each species. Organic apple juices were having lower content of S, Na, Cu, B i Ni than their conventional contra partners. Organic farming method favored higher accumulation of Ca, Mg, P, Na, Zn, Cu, B, Cd and Ni in organic currant juices. The only difference in pear juices was found analyzing Mg content. 'Bio' juices revealed lower amount of this element.

Key words: organic farming, nutritional value, fruit juices, nitrates, macroelements, microelements

INTRODUCTION

During recent decades consumers have started to be more aware and look for safer and better controlled foods. Hughner et al. [2007] offer a review of the literature pertaining to consumer attitudes toward organic foods. According to the author food safety,

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higher nutritional quality and environmental concerns are motivating factors for consumers to purchase organic products and develop the market. According to Köpke [2005] the consumer's well-being is based on the faith that by purchasing and eating organic food can contributes to a better future and improve environment. These effects with their social implications along with improved animal welfare may, in the end, be more important than any measurable contribution of balanced diets to individual nutritional health.

There have been many studies comparing crop quality obtained from the organic and conventional farming systems [Woëse et al. 1997, Worthington 2001, Bourn and Prescott 2002, Winter and Davis 2006, Peck et al. 2006, Rembiałkowska 2007, Benbrook et al. 2008, Dangour et al. 2009]. There is much controversy in obtained results concentrated on the nutritional quality of organic vs. conventional products. Many studies indicate that organic growing plants contain fewer nitrates and certain mineral components [Mader et al. 1993, Rembiałkowska 2000, Benbrook et al. 2008]. According to Dangour et al. [2009] there is no evidence of a difference in nutrient quality between organically and conventionally produced foodstuffs. The limited number of studies and variable obtained results make difficult to compose a general conclusion [Matt et al. 2011].

While there are many factors that can influence the nutrient contents of crops, the method of farming is also shown to be a strong influence, with the valid scientific studies demonstrating a trend toward significantly higher mineral contents, in organically grown than non-organically grown fruit and vegetables [Holden 2001].

Conventional fruit production is based on high inputs of pesticides and chemical fertilizers. This system can increase environmental pollution and diminish food safety. Organic orchard production is still quite limited, due mainly to the inadequate control of pest and diseases with organic alternatives. The diseases control program includes only copper, sulphur and some alternative products. This is a biggest concern in the organic orchard from a fruit quality aspect [Lind et al. 2003, Ferree and Warrington 2003].

Mineral compounds, including magnesium, phosphorus and trace elements like iron, manganese are vital in healthy diet. However, some studies comparing mineral content of fruits made from the 1930's to 1980's show continuous decreasing mineral content in respect of some essential elements like K, Mg, Fe and Cu [Mayer 1997]. This is linked with an intensification of fruit production in the last decades.

As fruit juices and soft drinks are some of the most widespread beverages in the habitual diet, and they can contribute to minerals and trace elements dietary intake we tried to assess the differences in element content of juices produced from organic and conventional vegetables.

MATERIAL AND METHODS

The comparative study on nutrient content of organic foods was conducted in the year 2009. The following conventional and organic crops were evaluated:

1. Apple (*Malus domestica* cv. 'Red Boskoop' grafted on M.26 rootstock),
2. Pear (*Pirus communis* cv. 'Bartlett' grafted on *Pirus communis* var. *caucasica*),
3. Black currant (*Ribes nigrum* cv. 'Tiben').

For the experiment 33 orchards producing organic and conventional fruits were chosen. The area of the trial covered four districts (Małopolskie, Podkarpacie, Mazowieckie and Lubelskie) located in the south and east of Poland. For each crop at least six matched-pair sets (conventional / organic) were established. The climate as well as soil conditions were similar for the each pair of farms. All organic sites were certified according to UE Council Regulation no. 2092/91 and obtained valid certificates. During the study the soil properties of each site were evaluated (granulometric, organic matter content, pH, EC as well as macro- and microelement content). In addition, crop rotation, fertilization routine, pest management and other cultural practices for each field were recorded. At harvest the total yield and an average weight of fruit was noted. Moreover, dry matter content, soluble solids content, and titratable acidity was measured [Gąstoł and Domagała-Świątkiewicz 2012].

Chemical analyses. Four samples of fruits from each field were taken. They were washed, sorted, trimmed in the usual manner and consequently crushed. Unclarified juices were obtained with cold press juicer (Tako PH-2). In the samples of juices the following parameters were investigated:

– ammonium nitrogen content and nitrate content after hot water (70^{o}C) extraction – FIA method,

– Collected juice samples were mineralized in 65% extra pure HNO_3 (Merck) in a CEM MARS-5 Xpress microwave oven [Pasławski and Migaszewski 2006]. Macroelements (P, K, Ca, Mg, S) and microelements (Cu, Fe, Zn, Mn, Sr, B) as well as heavy metals (Cd, Pb and Ni) content was assessed using ICP-OES technique (Teledyne Prodigy, Leeman Labs).

The determinations were made in triplicate for each sample.

Statistical analysis. The measurements were listed and subjected to a two-way analysis of variance. Differences between the means were ascertained with a multiple Duncan Test, using Statistica 9.0 software (Statsoft, Inc.). The mean values for the combinations labeled with the same letters do not significantly differ at the significance level $\alpha = 0.05$.

RESULTS AND DISCUSSION

Both analyzed factors: species and the farming method influenced mineral element content of fruit juices. Black currant juices were having the highest content of all investigated macroelements and trace elements (table 1, 2 and 3). However, for nitrates content no differences were found. In the case of calcium, iron and manganese the measured values for currants were 10 times higher than for others. The highest amounts of copper and cadmium were recorded for pear juices. Apple juices were the richest in boron.

Macronutrients. A comparative study by Worthington [2001] indicates a higher concentration of mineral elements (iron, magnesium and phosphorus) in organic raw material what is linked to higher soil microorganism content [Fliessbach and Mäder 2000]. Matt et al. [2011] report shows no clear conclusion in the case of fruits. In the Heaton review [2001] among 14 studies seven demonstrated a trend towards higher mineral content in organically grown crops, six revealed inconsistent or no significant differences.

Table 1. Mean nitrate, ammonium nitrogen and macroelement content (mg kg^{-1} f.m.) of investigated juices as influenced by different species
Tabela 1. Wpływ gatunku na średnią zawartość azotu azotanowego, amonowego oraz makroelementów (mg kg^{-1} ś.m.) w badanych sokach owocowych

Species – Gatunek	$N\text{-}NO_3$	$N\text{-}NH_4$	Ca	K	Mg	P	S
Apple – Jabłoń	1.5 a	10.1 a	28.9 a	939 a	23.2 a	74.1 a	30.7 a
Pear – Grusza	4.0 a	10.9 a	33.3 a	930 a	40.4 b	87.9 a	53.1 b
Black currant – Czarna porzeczka	0.87 a	60.7 b	329.6 b	2065 b	127.5 c	215.3 b	90.7 c

Table 2. Microelement content (mg kg^{-1} f.m.) of investigated juices as influenced by different species
Tabela 2. Wpływ gatunku na średnią zawartość mikroelementów (mg kg^{-1} ś.m.) w badanych sokach owocowych

Species – Gatunek	Fe	Zn	Cu	Mn	B
Apple – Jabłoń	0.65 a	0.33 a	0.25 a	0.21 a	1.72 b
Pear – Grusza	0.57 a	1.15 b	0.78 b	0.24 a	1.08 a
Black currant – Czarna porzeczka	6.31 b	1.34 b	0.31 a	3.10 b	1.53 b

Table 3. Sodium, strontium and heavy metals content (mg kg^{-1} f.m.) of investigated juices as influenced by different species
Tabela 3. Wpływ gatunku na średnią zawartość sodu, strontu oraz metali ciężkich (mg kg^{-1} ś.m.) w badanych sokach

Species – Gatunek	Na	Sr	Cd	Pb	Ni
Apple – Jabłoń	2.26 a	0.07 a	0.003 a	0.009 a	0.05 a
Pear – Grusza	1.60 a	0.08 a	0.008 b	0.010 ab	0.20 b
Black currant – Czarna porzeczka	13.88 b	1.36 b	0.007 b	0.015 b	0.21 b

Nitrogen. The concentration of nitrogen in examined juices was very low and ranged between 0.87 mg (black currant) to 4.0 mg $N\text{-}NO_3$ kg^{-1} f.m. (pear). No differences were found between conventional and organic fruit juices. The similar results demonstrated Woëse et al. [1997] in the review concerned with the summary and evaluation of the results from more than 150 investigations comparing the quality of conventionally and organically produced food. Many researchers [Rembiałkowska 2003, Guadagnin et al. 2005, Lester 2007, Dangour et al. 2009, Lairon 2010] have confirmed that the nitrate levels in plant crops are higher when nitrogen is supplied in high-dose inorganic fertilizers than when supplied from slowly mineralized organic manures.

Nitrates are a natural constituent in plants. Most of nitrogen in plants is taken up initially in the nitrate form soil. Accumulation of nitrate varies with plant organs. High levels of nitrate commonly found in leafy and root vegetables such as lettuce, spinach, beetroot and carrot. Fruits generally show a low level of accumulation of NO_3. The annual nitrogen requirements of fruit trees are relatively low (about 30 kg N ha^{-1}). Half of the N requirements in spring are met from the tree's own reserves [Lind et al. 2003]. In organic farming application of slow released nitrogen from organic sources do not increase accumulation of nitrates in orchard plants. Available data indicate that strawberries occasionally contained more than 100 mg nitrate per kg, grapes reached 17 mg, and concentrations in apples, pears, cherries ranged commonly from 0 to less than 10 mg NO_3 kg^{-1} [Schuddeboom 1993].

Calcium, magnesium and potassium. The cultivation method influenced **calcium** accumulation in black currant juices (table 6). Mean Ca content for organic samples was 363 mg Ca kg^{-1}, whereas for conventional only 254 mg Ca kg^{-1} f.m. However, for the rest of species no significant differences in calcium concentration in juices were found. These results are in agreement with Benbrook [2008] report of higher concentrations of minerals and other nutrients in organically grown crops. Also the results of Raigón et al. [2010] showed that organic management and fertilization have a positive effect on the accumulation of certain beneficial mineral compounds like K, Ca and Mg in eggplants. In contrast, DeEll and Prange [1993] in their farm survey found no significant differences in Ca and Mg content, whereas organically grown apples had higher concentration of P and K. Similarly, no impact of husbandry method on Ca content in 'Royal Gala' apples found Amarante et al. [2008]. However, the author proved lower K and Mg levels for organic fruits.

Organic juices revealed higher **magnesium** amounts. It was proved for pears (45.4 and 34.0 mg Mg kg^{-1} for 'bio' and conventional juices) and for currants (141 and 98 mg Mg kg^{-1}. f.m. respectively) (table 5 and 6). The similar effect found Weibel et al. [2000] for apple. However, in our study there was no impact of farming system on Mg content in apple juices.

Although we recorded some differences in blackcurrants **potassium** content caused by growing method (e.g. 2177 mg K *vs*. 1814 mg K kg^{-1} f.m. for organic and conventional, respectively), the differences were not statistically significant (table 6). Pither and Hall [1990] found higher levels of potassium content in organic apples. The fertilizing schedule followed by the organic orchardist support soil fertility in a holistic manner. This means providing sufficient and balanced amounts of nutrients. The soil structure and soil microbial activity are enhanced and maintained. A sufficient release of nutrients from soil reserves cause a high soil microbial activity making them available for root uptake [Ferree and Warrington 2003]. Probably for this reason some studies demonstrate a trend toward significantly higher nutrient mineral content in organically grown crops.

Phosphorus and sulphur. The cultivation method on **phosphorus** content was recorded merely in black currant. Organic juices reached 242 mg P, whereas conventional only 154 mg P kg^{-1} f.m. (table 6). This relationship was correlated with higher level of soil phosphorus in organic black current fields (data not presented). Weibel et al. [2000] compared the dry matter, mineral (P, K, Ca, Mg and Se) content in apples from organic and conventional farming systems. The data showed higher phosphorus content for organic apples (increase of one-third), whereas no differences were found in the K, Ca, Mg and Se levels. Phosphorus solubility is low in the most of soils. A varied crop rotation in organic farming as well as animal manures, green manures and compost applied lead to optimal soil biological activity. Under organic management colonization by mycorhizal fungi are greatly increased, which are very important for feeding orchard plants. This increases the utilizable root space and enhances P uptake by plant [Hildermann et al. 2010]. However, in conventional farming used soluble phosphorus fertilizers promote high phosphorus uptake of plants.

As far as **sulphur** content is concerned, the higher level was noted for conventional apple juices (37.4 mg S kg^{-1} f.m.) as compared to organic ones (25.1 mg S kg^{-1} f.m.) (table 4). For the rest of fruits no significant differences were found between orchard management systems. Many orchards have significant natural inputs of sulphur from mineralization of soil organic matter, with precipitation, irrigation, and unintended applications of S with sulphur-containing fertilizers and pesticides. Most organic amendments also have large sulphur content [Ferree and Warrington 2003, Eriksen 2005].

Table 4. Nitrate, ammonium nitrogen and mineral element content (mg kg^{-1} f.m.) of juices made from organically and conventionally produced apples

Tabela 4. Wpływ sposobu uprawy na średnią zawartość azotu azotanowego, amonowego oraz makroelementów (mg kg^{-1} ś.m.) w soku z jabłek

Element Składnik	Cultivation method Metoda uprawy		Element składnik mg kg^{-1}	Cultivation method Metoda uprawy	
	organic ekologiczna	conventional konwencjonalna		organic ekologiczna	conventional konwencjonalna
$N\text{-}NO_3$	1.6 ± 0.3 a	1.3 ± 0.2 a	Fe	0.63 ± 0.12 a	0.66 ± 0.26 a
$N\text{-}NH_4$	10.5 ± 4.4 a	9.7 ± 2.2 a	Zn	0.30 ± 0.08 a	0.37 ± 0.08 a
Ca	23.0 ± 6.6 a	36.1 ± 13.0 a	Cu	0.23 ± 0.03 a	0.28 ± 0.03 b
K	934 ± 89 a	945 ± 127 a	Mn	0.18 ± 0.07 a	0.23 ± 0.06 a
Mg	22.1 ± 6.1 a	24.5 ± 5.0 a	B	1.44 ± 0.32 a	2.06 ± 0.32 b
P	74.3 ± 8.4 a	73.9 ± 10.3 a	Cd	0.003 ± 0.001 a	0.003 ± 0.0005 a
S	25.1 ± 5.5 a	37.4 ± 6.3 b	Pb	0.010 ± 0.003 a	0.008 ± 0.005 a
Na	2.00 ± 1.2 a	9.36 ± 9.1 b	Ni	0.04 ± 0.005 a	0.06 ± 0.015 b
Sr	0.02 ± 0.005 a	0.12 ± 0.01 a			

Sodium and trace elements. Studies on mineral content of fruits have not given any clear conclusion. Some have reported no differences between organic and conventional [Woëse et al. 1997, Bourn and Prescott 2002], whereas Smith et al. [1993] reported higher micronutrient levels for organically grown apples and pear.

Although, the measured **sodium** levels were low, some differences between fruit juices were observed. Conventional apple juices contained more sodium than organic (9.36 *vs*. 2.00 mg Na kg^{-1}), whereas the reverse was true for currants (7.00 mg Na kg^{-1} *vs*. 16.9 mg Na kg^{-1}) (table 4 and 6). Pear juices revealed the lowest sodium content, in this case no influence of farming system was observed (table 5). An agrotechnical factor, mainly fertilization, strongly affects mineral content of crops. In conventional farming easy-dissolvable fertilizers are used. Soil solution ions are easily absorbed by root hairs. Very soluble sodium is present in many mineral fertilizers and it is rapidly taken up by plants.

Table 5. Nitrate, ammonium nitrogen and mineral element content (mg kg^{-1} f.m.) of juices made from organically and conventionally produced pears
Tabela 5. Wpływ sposobu uprawy na średnią zawartość azotu azotanowego, amonowego oraz makroelementów (mg kg^{-1} ś.m.) w soku z gruszek

Element Składnik	Cultivation method Metoda uprawy		Element składnik mg kg^{-1}	Cultivation method Metoda uprawy	
	organic ekologiczna	conventional konwencjonalna		organic ekologiczna	conventional konwencjonalna
$N-NO_3$	5.6 ± 1.8 a	2.4 ± 0.9 a	Fe	0.54 ± 0.10 a	0.60 ± 0.14a
$N-NH_4$	9.3 ± 2.9 a	12.6 ± 4.89 a	Zn	0.62 ± 0.16 a	1.81 ± 1.18 a
Ca	34.0 ± 5.9 a	32.4 ± 8.5 a	Cu	0.68 ± 0.19 a	0.90 ± 0.36 a
K	959 ± 84 a	894 ± 38 a	Mn	0.24 ± 0.06 a	0.23 ± 0.08 a
Mg	45.4 ± 4.7 b	34.0 ± 7.2 a	B	1.15 ± 0.41 a	0.98 ± 0.43 a
P	95.0 ± 12.1 a	79.0 ± 8.2 a	Cd	0.007 ± 0.001a	0.007 ± 0.001 a
S	42.0 ± 24.0 a	66.9 ± 37.0 a	Pb	0.010 ± 0.006 a	0.010 ± 0.003 a
Na	2.45 ± 2.74 a	0.52 ± 0.47 a	Ni	0.19 ± 0.03 a	0.22 ± 0.03 a
Sr	0.07 ± 0.01 a	0.08 ± 0.04 a			

The concentration of **iron** in examined juices ranged from 0.57 (pear) to 6.31 mg Fe kg^{-1} f.m. (black currant) (table 3). The cultivation system had no impact on iron juice content. The study of Woëse et al. [1997] showed organically grown of vegetables had higher Fe content.

The similar effect, no influence of a farming system on mineral fruit juice content in case of **strontium** was found. The concentration ranged between 0.07 (apple) to 1.36 mg Sr kg^{-1} f.m. (black currant) in analyzed fruit juices (table 2). Strontium is chemically similar to calcium, and its biogeochemical cycles are comparable. Poor Sr immobilization by soils leads to large availability for plants. Plant foods containing Sr range from very low *e.g* in corn (0.4 mg Sr kg^{-1} d.m., to high, *e.g.* in lettuce (74 mg Sr kg^{-1} d.m.). In apples strontium content varied between 0.5–1.7 with the average 0.9 mg Sr kg^{-1} [Kabata-Pendias 2011].

The concentration of **zinc** in fruit juices ranged between 0.33 (apple) – 1.34 mg Zn kg^{-1} f.m. (black currant) (table 2). Organically produced currant juices contained more zinc

(1.44 mg Zn kg^{-1} f.m.) as compared to their conventional contra partners (1.13 mg Zn kg^{-1} f.m.) (table 6). The anthropogenic sources of Zn (atmospheric deposition, organic and mineral fertilizers, pesticides, sewage sludge) can raise concentration of this element in top soils in agricultural area. The references for food composition in the US gives for Zn values in fruits a range: 0.4–3.0 mg Zn kg^{-1} (grapes and black current, respectively) [Kabata-Pendias 2011].

Table 6. Nitrate, ammonium nitrogen and mineral element content (mg kg^{-1} f.m.) of juices made from organically and conventionally produced black currants

Tabela 6. Wpływ sposobu uprawy na średnią zawartość azotu azotanowego, amonowego oraz makroelementów (mg kg^{-1} ś.m.) w soku z czarnych porzeczek

Element Składnik	Cultivation method Metoda uprawy		Element składnik mg kg^{-1}	Cultivation method Metoda uprawy	
	organic ekologiczna	conventional konwencjonalna		organic ekologiczna	conventional konwencjonalna
$N\text{-}NO_3$	0.41 ± 0.09 a	1.7 ± 0.45 a	Fe	6.05 ± 2.5 a	6.90 ± 1.72 a
$N\text{-}NH_4$	45.7 ± 8.2 ab	86.8 ± 15.1 bc	Zn	1.44 ± 0.14 b	1.13 ± 0.26 a
Ca	363 ± 47 b	254 ± 47 a	Cu	0.40 ± 0.10 b	0.11 ± 0.03 a
K	2177 ± 171 a	1814 ± 402 a	Mn	3.11 ± 0.36 a	3.10 ± 0.64 a
Mg	141 ± 10.8 b	98 ± 21 a	B	1.70 ± 0.22 b	1.15 ± 0.27 a
P	242 ± 25.0 b	154 ± 37 a	Cd	0.008 ± 0.001 b	0.006 ± 0.001 a
S	95.7 ± 16.8 a	79.4 ± 16.0 a	Pb	0.017 ± 0.05 a	0.011 ± 0.0001 a
Na	16.9 ± 4.2 b	7.00 ± 0.8 a	Ni	0.23 ± 0.02 b	0.15 ± 0.02 a
Sr	1.45 ± 0.18 a	1.15 ± 0.27 a			

The higher **copper** amounts were measured in conventional apple juices (0.28 mg Cu *vs*. 0.23 mg Cu kg^{-1} f.m. for organic) (table 4). However, the opposite we proved for currants (0.11 mg Cu kg^{-1} and 0.40 mg Cu kg^{-1}, respectively). In conventional pear juices only a slight tendency to increasing Cu content was observed (table 5). Several significant sources such as fertilizers, sewage sludge, manures, agrochemicals (fungicides) have contributed to increased Cu levels in agricultural soils and plant foods. The recent references for food composition in the United States give values for Cu in fruits: 0.3–4.0 (grapes and avocados, respectively) [Kabata-Pendias 2011].

The boron content in analyzed fruit juices varied from 1.08 (pear) to 1.72 mg B kg^{-1} f.m. (apple) (table 2). The same pattern like in the case of copper – increased content in conventional apple juices and organic black currant juices as compared to contra partners we found for **boron**. Boron is essential element needed for the plant. Some crops such as sugar beet, celery, sunflower and apple have a high B requirement. Also, in our study we measured higher boron content in apples and currants.

Although species varied in **manganium** content (ten times more Mn for currants), no impact of husbandry method was found.

The heavy metals concentration in measured samples was very low. **Cadmium** content ranged between 0.003 (apple) – 0.008 mg Cd kg^{-1} f.m. (pear) (table 3). No influence of farming system on cadmium level was found except black currant juice (table 6). Organic currant juices had higher level (0.008 mg Cd kg^{-1} f.m.) than conventionally produced (0.006 mg Cd kg^{-1} f.m.). As compared to conventional farms higher level of soil phosphorus for black currant organic plantations was determined (data not presented). These results could indicate the effect of P fertilization on increased plant Cd level. Phosphate fertilizers, also phosphate rock used in organic farming, and liming materials derived from industrial waste often contaminated by cadmium and others heavy metals. It might be expected that organic production without industrial waste and trace mineral fertilizers would guarantee lower amounts of heavy metals in crops. Report of Matt et al. [2011] demonstrated that studies have not shown distinct differences in the heavy metal content between organic and conventional plant materials. The ambiguous results in Cd level indicate the need for further study of the agriculture factors determining the Cd level in plant crops [Rembiałkowska 2000].

No differences in **lead** level in fruit juices were found. The concentration of this metal vary between 0.009 (apple) to 0.015 mg Pb kg^{-1} f.m. (black currant) (table 3). The results of Rossi et al. [2008] study show organic tomatoes had higher Cd and Pb levels but a lower Cu content that conventionally ones. Kabata-Pendias [2011] concluded a relatively minor effect of the Pb soil concentration due to agricultural activity. Also Rembiałkowska [2000] pointed out that many studies not shown distinct differences in heavy metals between 'bio' and conventional foods.

Nickel content in analyzed fruit juices varied between 0.05 (apple) to 0.21 mg Ni kg^{-1} f.m. (black currant) (table 3). Conventional apple juices reached the higher **nickel** level (0.06 mg Ni kg^{-1} f.m.) than organic (0.04 mg Ni kg^{-1} f.m.) (table 4). The reverse trend we recorded for currant juices: 0.15 mg Ni and 0.23 mg Ni kg^{-1} f.m. for organic ones. Nickel is considered as serious pollutants. Except of metal processing, combustion of coal and oil, also sewage sludge and phosphate fertilizers may be importance source of Ni in agricultural soils [Kabata-Pendias 2011]. According to Ericsson [2001] in food plants, nickel concentration ranged from 0.06 (apple) to 2.0 mg Ni kg^{-1} f.m. (cucumber).

CONCLUSIONS

1. Obtained results indicate that both analyzed factors: species and system of farming influenced mineral content of investigated juices.

2. Black currant juices contained the highest amounts of: Ca, K, Mg, P, S, Fe, Mn and Na. In the case of Ca, Fe and Mn the measured levels were ten times higher than for other juices. The highest content of Cu was proved for pear, whereas apple juices revealed the highest B amount.

3. The husbandry method also influenced the mineral content of the juices, however in different manner for each species. Organic apple juices were having lower content of S, Na, Cu, B and Ni than their conventional contra partners. For the organic currant juices the reverse trend was proved. They contained more Ca, Mg, P, Na, Zn, Cu, B, Cd

and Ni than conventional juices. The only difference in pear juices was found analyzing Mg content. 'Bio' juices revealed lower amount of this element.

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PORÓWNANIE SKŁADU MINERALNEGO SOKÓW Z JABŁEK, GRUSZEK I CZARNEJ PORZECZKI UPRAWIANYCH METODAMI EKOLOGICZNĄ I KONWENCJONALNĄ

Streszczenie. Porównanie wpływu uprawy konwencjonalnej i ekologicznej na właściwości soków z jabłek, gruszek i porzeczki czarnej prowadzone było w roku 2009. Analizami objęto 33 plantacje zlokalizowane w czterech województwach: małopolskim, podkarpackim, mazowieckim oraz lubelskim. Wszystkie gospodarstwa prowadzące uprawy ekologiczne posiadały ważne certyfikaty zgodne z rozporządzeniem EU 2092/91. Z uzyskanych owoców tłoczono soki mętne, w których po mineralizacji mikrofalowej w HNO_3 oznaczono zawartość składników pokarmowych: P, K, Mg, Ca, S, Fe, Zn, Mn, Cu, B, jak również Na, Cd, Pb i Ni (metodą ICP-OES). Ponadto oznaczono zawartość azotu amonowego i azotanowego metodą FIA. Analizowane czynniki: gatunek oraz sposób uprawy wpłynęły istotnie na zawartość oznaczonych składników mineralnych. Soki z porzeczki czarnej zawierały najwięcej: wapnia, potasu, magnezu, fosforu, siarki, żelaza, cynku i manganu oraz sodu. W przypadku wapnia, żelaza i manganu były to zawartości prawie 10-krotnie wyższe. Najwyższą zawartość miedzi oraz kadmu oznaczono w sokach z gruszek. Sok z jabłek wyróżniał się wysoką zawartością boru. Sposób uprawy wpływał istotnie na średnią zawartość badanych pierwiastków w sokach jabłkowych. Soki wyprodukowane z surowca ekologicznego zawierały mniej S, Na, Cu, B i Ni. Przeciwną tendencję: wyższe zawartości Ca, Mg, P, Na, Zn, Cu, B, Cd i Ni w sokach ekologicznych udowodniono w przypadku czarnej porzeczki. Dla soków gruszkowych udowodniono tylko różnicę w zawartości magnezu – soki ekologiczne zawierały mniej tego pierwiastka.Ca, K, Mg i P.

Słowa kluczowe: sadownictwo ekologiczne, wartość odżywcza, soki owocowe, azotany, makro- i mikroelementy

ACKNOWLEDGEMENTS

The project was financed by the Polish Ministry of Agriculture and Rural Development (project no. RR-re-401-25-173/09)

Accepted for print – Zaakceptowano do druku: 16.01.2011