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Strawberries From Integrated and Organic Production: Mineral Contents and Antioxidant Activity

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Abstract

As the nutritional quality of food is becoming increasingly more important for consumers, significant attention needs to be devoted to agricultural practices and their influences on the nutrient contents in food. The presented investigation studied the mineral contents and antioxidant activities in the fruits of four organically-grown strawberry cultivars ‘St. Pierre’, ‘Elsanta’, ‘Sugar Lia’ and ‘Thuchampion’ when compared to those of integrated-grown plants. The strawberries were digested and analyzed for K, Mg, Fe, Zn, Cu, and Mn using an atomic absorption spectrometer, whilst P was analyzed using a vanadate-molybdate method. In addition, antioxidant activity was estimated by using the ABTS assay. The results showed that the mineral contents and antioxidant activities in strawberries depends on the cultivar, and its production system. Organically-grown fruits showed higher antioxidant activities and Cu content than the integrated fruits, whilst the integrated fruits were superior in their contents of P, K, Mg, Fe and Mn. All the cultivars showed similar Zn content, probably reflecting the fact that the Zn content in strawberries does not depend on the cultivar.

Keywords: Strawberries, minerals, antioxidant activity, production system

1. Introduction

Strawberries (*Fragaria* spp.) are one of the more consumed fruits due to their unique flavour. They have high economic value and are a well-known source of essential nutrients (K, P, Mg, Ca), vitamin C, and phenolic compounds, most of which are natural antioxidants and may have physiological effects on humans.

Conventional and integrated farming systems are the primary practices used in the production of fruits throughout Slovenia, whereas organic fruit production accounts for 798.03 ha (app. 7.25%).[1] The farming systems differ mostly in regard to plant protection and fertilization strategies, and are managed in accordance with the laws and rules defining each farming system.[2–4] A detailed description of the differences between farming systems is provided by Bavec et al.[5]

Consumer demand for organically-grown food has increased over the last decade. One reason is probably an increase in the availability of such foods on the market and the others, according to surveys are, that consumers tend to believe that these foods are more nutritious and safer. The vast majority (94–100%) of organic food does not contain any pesticide residues and the nitrate content is far less than in conventionally-grown crops.[6–8] These factors are usually more important when deciding to purchase organic food than any concerns about environmental contamination, although these priorities can change according to the country and the populations’ ages.

Over the recent years, studies have tended towards comparing the contents of nutrients in strawberries grown under different agro-ecosystems. These reports, however, are contradictory. Reganold et al.[9], for example, demonstrated that strawberries grown organically had lower concentrations of phosphorous and potassium, and higher antioxidant activity, ascorbic acid content and phenolic compounds than the conventionally-grown strawberries. Several studies reported on higher antioxidants levels in organically-grown strawberries,[10–12] whereas other studies demonstrated only small and inconsistent differences in minerals and vitamin C contents,[13] levels of phenolic compounds,[14] sugar content, and antioxidant activity.[15]

There is still a lack of conclusive evidence that organically-produced foods are more health-promoting because the differences between the products from the two systems are insufficiently consistent. Further studies are thus necessary in order to gather more data on this topic. The objective of this work was to study the content of selected minerals and to estimate antioxidant activities in four strawberry cultivars grown under both integrated and organic production systems. In addition, the levels of extractable nutrients in the soils from both farming systems were compared with the fruits mineral contents.

2. Experimental

2. 1. Trial Sites

The presented study was carried out in 2009 in collaboration with two professional strawberry growers. The organic farm (OF) was located in the Southern part of Slovenia, in Brežice (45°54'N, 15°35'E), whereas the farm managed in accordance with integrated fruit production practices (IFP) was located in the North-Eastern part of Slovenia, in Maribor (46°33'N, 15°38'E). Both growers had managed their farms as organic or integrated for more than five years. These farms were chosen because they produced the same strawberry cultivars, even though, the climatic conditions on the trial sites differed (Table 1).

Table 1. Total monthly precipitation, and monthly air temperature.

Month	Precipitation (mm)		Temperature (°C)	
	Maribor	Novo mesto*	Maribor	Novo mesto*
March	67	77	6.5	6.7
April	42	141	13.7	13.0
May	130	62	17.1	17.5
June	165	83	18.5	18.7

* nearest representative meteorological station to the organic farm in Brežice

2. 2. Soil Sampling and Analyses

The soils were sampled in May 2009 and analyzed from the top (0–20 cm). Each sample was a composite of 20 sub-samples taken at random. The composite samples were air-dried and sieved through a 2 mm mesh. The plant available P and K contents of the soils were extracted using ammonium lactate extraction solution at 1 : 20 soil to extractant ratio. The P concentration in the filtrate was determined according to ÖNORM L1087.[16] The plant available Mg was extracted by following the Schachtschabl procedure: 25 mL of $CaCl_2$ solution (0.0125 mol L^{-1}) was added to 5 g of the air-dried soil sample and suspension was extracted for 2 h on a horizontal shaker.[17] The concentrations of the plant available Fe, Cu, Mn, and Zn were determined in extracts obtained after the extraction of 10 g of soil sample with 100 ml EDTA solution (0.05 mol L^{-1}).[18] The mineral element concentrations were measured using the AAS (Varian SpectrAA-10), except for K where AES was applied. In Brežice there were slightly acidic soil reaction (pH($CaCl_2$) = 6.30), whilst in Maribor the soil reaction was acidic with a pH value in $CaCl_2$ of 5.75. The extraction was done in triplicate for each sample. The results were expressed as mg kg^{-1} of dry weight (DW).

2. 3. Strawberry Sampling and Analyses

The completely ripe fruits (exhibited an intense red colour all over the fruits) of four strawberry cultivars, 'St. Pierre', 'Elsanta', 'Sugar Lia', and 'Thuchampion' were collected in May 2009. For each cultivar one kilogram of fruit was randomly collected from the field, frozen by pouring in liquid nitrogen and then homogenized using a blender (Grindomix GM 200, Retsch). Only fruit of uniform size, colour, free from defects such as decay, shrivelling and bruising were used for analyses. Approximately 1 g of the homogenised sample was weighed into a 50 mL centrifuge tube, and stored at –75 °C until extraction.

Moisture Content

The moisture content of randomly selected fruit samples was determined by weighing the sample in Petri dishes before and after drying in the oven at 100 °C to a constant weight.

Mineral Elements

Approximately 6 g of homogenate was accurately weighed in PTFE vessels, treated with HNO_3 (5 mL, 69–70%, J. T. Baker, Suprapure) and H_2O_2 (0.5 mL, 30% Fluka), and digested in a microwave oven (CEM, Model MDS 2000) using the previously described digestion programme.[19] The digested samples were analysed by AAS or AES. Two commercial reference materials (NIST 8433 and NIST 1547) were used as the quality control samples. The accuracy was sufficient for all of the mineral elements (data not presented). Each sample was analyzed in triplicate and the results expressed as mg kg^{-1} of fresh weight (FW).

Estimation of Total Antioxidant Activity

Thirty mL of acetone: water (70:30, v/v) was added to the homogenized berries in order to prepare extracts for the estimation of total antioxidant activity. Samples were vortexed for 1 min and then the extraction was performed following the procedure previously described.[20] Supernatants were combined in a 100 mL volumetric flask. The extraction was done in triplicate for each sample.

Antioxidant activity was evaluated using the ABTS assay, by following the same procedure used for the estimation of antioxidant activity in plum extracts.[21] The experiments were performed in duplicate and the absorbance was monitoring at 734 nm (Cary 1E Varian UV/Vis spectrophotometer). The vitamin E analogue

Trolox was used as standard. The results were expressed as μmol of Trolox equivalent (TE) per gram of fresh weight (FW).

2. 4. Statistical Analysis

Data for mineral elements contents in the soil and the strawberries were subjected to the analysis of variance (ANOVA) using the Statgraphics Centurion (Version XV, StatPoint Technologies, Inc., Warrenton, VA). Differences among the means were determined by Duncan's multiple-range test ($\alpha = 0.05$). The results are presented as means of three replications ± standard error of the mean (±SEM).

3. Results and Discussion

3. 1. Mineral Contents in Soil

The mineral contents in the soil of both the organic and integrated strawberry farms are presented in Table 2. The organically-managed soil compared to its integrated counterpart contained significantly higher concentrations of extractable manganese (2.7-fold), magnesium (2.3-fold), iron (1.7-fold), and copper (1.7-fold). The soil from the farm managed in accordance with integrated fruit production practices, on the other hand, was superior to the organic farm in its concentrations of phosphorus (12.5-fold), potassium (3-fold), and zinc (2.1-fold). Significantly lower amounts of extractable P and K in organically managed soil could be due to long-term (more than 5 years) low-input of organic amendment. Several authors have reported similar results to those obtained in our study. Vestberg et al.[22] and Gosling and Shepherd[23] reported a lower concentration of extractable P and K in organic compared with conventionally managed soils after long-term organic management. A study of compost versus conventionally fertilized vegetable plots, which was conducted for 12 years, showed that soils with compost had higher pH, and Mehlich-3 extractable levels of Ca, Mg, Mn, Zn and B compared with the fertilized plots.[24] Higher contents of Ca, Mg, Mn, B, Cu and K in soils amended with alternative than synthetic fertility amendments were found in the studies of Wang and Lin,[25] Bulluck et al.[26] and Liu et al.[27] with the exception of K for which the values were more variable among organic, sustainable and conventional farms. Organically managed surface soils contain higher levels of extractable Zn, B, and Na, and notably higher Fe levels.[9] Different production areas with similar temperatures, different average monthly rainfall (Table 1), and complex interactions of physical, biological and chemical processes in soil has made it very difficult to draw any general conclusion on the effect of agricultural practices on extractable soil mineral contents. However, the results do offer support to the argument that organic farming is mining reserves of P and K built up by conventional management.

Table 2. Mineral element contents in the soils at 0–20 cm depth from the organic and integrated strawberry farms (average ± SEM).

Mineral element	Organic production (mg kg^{-1} DW)	Integrated production (mg kg^{-1} DW)
P*	22 ± 0.4	269 ± 1
K*	107 ± 3	328 ± 6
Mg*	232 ± 4	100 ± 1
Fe*	812 ± 4	480 ± 5
Cu*	15.2 ± 0.5	9.0 ± 0.3
Zn*	8.1 ± 0.1	17.0 ± 0.5
Mn*	401 ± 1	146 ± 1

* Means within particular elements are significantly different at $P < 0.05$.

3. 2. Dry Matter

Dry matter content of the fruits differed among cultivars (Table 3). Organically grown strawberries had higher dry matter content than those grown under integrated production system. The highest dry matter content was obtained in 'Sugar Lia' followed by 'Elsanta' and other cultivars. Higher dry matter content means higher nutrients content of fresh berries.

Table 3. Dry matter (DM) content (%) of the four strawberry cultivars from integrated and organic production system.

	Integrated	Organic
'St. Pierre'	7.9	8.2
'Elsanta'	8.7	9.1
'Sugar Lia'	9.1	9.6
'Thuchampion'	8.1	8.6

3. 3. Mineral Contents and Antioxidant Activity of the Fruits

The mineral elements contents and antioxidant activities were studied in four strawberry cultivars 'St. Pierre', 'Elsanta', 'Sugar Lia', and 'Thuchampion', which were produced within integrated and organic manner. The comparisons were performed either among four cultivars grown under the same system or between the production systems.

The results for mineral contents and antioxidant activities in both the organically and integrated-grown strawberries, are shown in Table 4 and Figure 1. The main minerals found in all the cultivars were K, P, and Mg. It was noticeable that the most abundant nutrient within all the strawberries studied was K, being present at an app. 5.5-fold higher concentration than P. The 'Thuchampion' fruits from both systems had the highest content of K (1848 mg kg^{-1} in integrated and 1643 mg kg^{-1} in organic fruits). No statistically significant differences were observed regarding K content among the other cultivars grown under OF, whilst the integrated-grown fruits of 'St. Pierre' showed a significant difference in K content (Figure 1). The K values for those fruits produced under IFP ranged from 1335 mg kg^{-1} FW in 'Sugar Lia' fruits to 1497 mg kg^{-1} FW in 'St. Pierre'. The content of P varied from between 182 mg kg^{-1} FW to 257 mg kg^{-1} FW and these values were obtained from organically-grown 'Sugar Lia' and 'St. Pierre' grown under IFP, respectively. However, the P contents showed no significant difference when comparing the cultivars 'Thuchampion', 'St. Pierre' and 'Sugar Lia' grown under IFP or 'Elsanta' and 'Sugar Lia' grown under OF. Furthermore, statistically significant differences in Mg content ($P < 0.05$) were observed among cultivars grown under both production systems. In cultivars produced by IFP the Mg content decreased in the order 'Thuchampion' > 'St. Pierre' > 'Sugar Lia' > 'Elsanta'. The ranking order for organically managed cultivars was the same, with the exception of 'Sugar Lia' in which the lowest Mg content was found. In regard to the Fe content, no significant differences were observed between 'Thuchampion' and 'St. Pierre', regardless of the production system. The Mn content in the integrated fruits was from 1.75 mg kg^{-1} FW in 'Elsanta' to 2.33 mg kg^{-1} FW in 'St. Pierre', whilst in the organic fruits the Mn contents were lower and ranged from 0.76 mg kg^{-1} in 'Sugar Lia' to 2.03 mg kg^{-1} in 'Thuchampion'. Reganold et al.[9] reported mean values for the mineral composition of strawberry cultivars 'Diamante', 'Lanai' and 'San Juan', which are similar to the presented data, with the exception of Zn the mean contents of which were found to be lower. Recamales et al.[28] analyzed the cultivar 'Camarosa' and obtained lower content of K and higher contents of P, Mg, Fe, Cu, Mn, and Zn. In the presented study, all the cultivars showed similar Zn values, probably reflecting that the Zn content in strawberries does not depend on the cultivar. However, the results obtained for all other minerals and from most comparative studies showed that the cultivar could be defined as an important factor affecting mineral contents. Differences in concentrations of P, K, Mg, and Ca among organically-grown strawberry cultivars have been previously reported.[29]

The average Mg content in fruits grown under the integrated-system (119 mg kg^{-1} FW) was significantly higher than that of the organically grown fruits (97 mg kg^{-1} FW). Similarly, in strawberries grown under IFP, higher contents of P (262 and 225 mg kg^{-1} FW), Fe (2.51 and 2.19 mg kg^{-1} FW, respectively), Mn (2.11 and 1.28 mg kg^{-1} FW, respectively), and Zn (1.19 and 0.99 mg kg^{-1} FW) were measured when compared to the organically-grown fruits, whilst the content of Cu was lower in IFP (0.29 mg kg^{-1} FW vs. 0.36 mg kg^{-1}). As the cultivars were not grown in the same soil, the differences in mineral contents between cultivars were possibly overcome not only by the production system (Table 4), but by the other factors such as differences in climate and soil conditions. The literature data are inconsistent regarding the mineral contents in fruits from different farming systems. Hakala et al.[13] and Hargreaves et al.[15] reported that elemental concentrations in strawberry fruits were unaffected by different soil management. The data obtained in our study are consistent with those previously reported by Reganold et al.[9], who found lower contents of P and K in organically-produced strawberries.

Although during our experiment an attempt was made to find a relationship between the soil extractable minerals and their content in fruits, nevertheless, only contradictory results were obtained. The content of Mg, Fe and Mn in the soil under the OF system was higher compared to that under IFP, but their contents were higher in strawberry fruits under IFP. Increases in concentrations of plant available soil minerals did not generally affect the strawberry uptake of nutrients, except for K, P, Zn, and Cu. In the integrated soil, extractable K was present at much higher concentration than in the organically-managed soil and also statistically significant higher values were found in the berries. The same trend was observed for Cu with higher concentrations in the OF managed soil and strawberries, as well as for P and Zn with higher concentrations in the integrated-managed soil and fruits. The present findings that increases in soil nutrients do not always result in increased plant nutritional concentration are consistent with those of other researchers.[15,24,25] Numerous complex, dynamic and interacting factors including pH, organic matter, concentration of competing ion effects, microbial activity, and plant genotype influence the quantities of minerals in fruits and edible portions of crops therefore the interpreation of obtained results is very difficult.

Many phytochemicals in strawberries have antioxidant activity.[30,31] The major phenolic compounds are procyanidins, ellagitanins, (+)-catechin, and *p*-coumaroyl esters.[32,33] A recent study has identified a total of 52 phenolic compounds in fruits, rhizomes and leaves of the white strawberry.[34] The literature showed that the single most important contributor to the total antioxidant activity (TAC) of strawberries was ascorbic acid (24 to 30%), also polar antioxidants, likely belonging to the class of phenolic acids, were found to contribute significantly to the TAC, whilst *p*-coumaric acid, kaempferol derivatives and two quercetin derivatives did not contribute significantly to the TAC of strawberries. The contribution of anthocyanins and ellagic acid derivatives to the TAC was evident, but differed strongly among cultivars.[35,36] Individual antioxidants studied in clinical trials do not appear to have consistent preventive effects.[31] Recently, there is growing evidence that reactions among several antioxidant molecules may have synergistic and additive effects, and therefore the measurement of TAC derived from combinations of individual antioxidants that occur in fruits potentially could provide a better estimate of the overall contributions of antioxidant components.[31,37–39]

Variations in antioxidant activity were found among the fruits of different cultivars (Table 4, Figure 1). The organicall-grown strawberries 'Elsanta' had the highest antioxidant activity (65.6 µmol TE g^{-1} FW), followed by 'Thuchampion' (62.0 µmol TE g^{-1} FW), 'St. Pierre' (56.3 µmol TE g^{-1} FW), and 'Sugar Lia' (37.6 µmol TE g^{-1} FW). The ranking order of antioxidant activity for integrated-grown berries was the same as for the organically-produced fruits and varied from 38.7 µmol TE g^{-1} FW to 54.0 µmol TE g^{-1} FW, but no significant difference in antioxidant activity was observed among 'Elsanta' and 'Thuchampion'. These results are much in agreement with those of Fernandez et al.[11] who reported that the organic farming strawberry extracts systematically showed higher radical scavenging activities than the integrated pest management strawberries extracts. Among studied phenolic compounds, the anthocyanins were the only phenolics to be significantly affected by the different agricultural practices.[11] Reganold et al.[9], Olsson et al.[10], and Jin et al.[12] reported significantly higher antioxidant activity in organically grown strawberries, which is in agreement with the results from the presented study, in which the average estimated antioxidant activity was significantly higher in organically-grown strawberries (15.8% higher) as compared to integrated fruits (Table 4). It has been suggested that organic farming may cause elevated levels of plant secondary metabolites, because of a tendency to increase the environmental stress on the plant and the activity of phenylalanine ammonialyase (PAL).[40] The findings of Tulipani et al.[41] showed that the response to environmental stress conditions is genotype dependent. Although the majority of studies reported on increased TAC in organic fruits, some studies found the similar TAC in organically and conventionally grown strawberries[15] or concluded that organic cultivation had no consistent effect on the levels of phenolic compounds in strawberries.[14]

In our study, the strawberries were grown at two different locations, so the cultivation site may also have affected the results which should be considered tentative. Häkkinen et al.[14] found that the strawberries cultivated in Finland had a significantly higher content of phenolic compounds compared to those cultivated in Poland, with the exception of 'Senga Segana' for which no regional differences in the phenolic contents were found. No differences in total anthocyanin concentration or total phenolic content were observed for 'Senga Segana', 'Polka' and 'Frida' grown at two locations in Norway, whilst 'Korona' and 'Florence' differed significantly in total anthocyanins.[42]

The comparison of antioxidant activity obtained in this study with those of other studies would be important, however, there are many sources of variation in antioxidant activity of fruits like geographic and environmental conditions, genetics, harvest season, as well as differences in sample preparation, extraction solvents, extraction temperatures, processing after extraction and reaction times with $ABTS^{\bullet +}$ which make direct comparisons difficult. Using the same method over a shorter reaction time (1 min) Capocasa et al.[43] reported antioxidant activity determined in aqueous-ethanol extracts of 20 strawberry genotypes of between 11.2 µmol TE g^{-1} FW ('Irma'), and 18.4 µmol TE g^{-1} FW ('Sveva'), whilst the antioxidant activity determined in acetone extracts of cultivar 'Honeoye' was reported to be 23.0 µmol TE g^{-1} FW.[44] Higher antioxidant activity (33.2 µmol TE g^{-1} FW) was observed in wild strawberries[45] and in eight strawberry varieties purchased in the markets at the United States with an average value of 35.8 µmol TE g^{-1} FW.[46]

Table 4. Mineral elements content (mg kg^{-1} FW) and antioxidant activities (µmol TE g^{-1} FW) in fruits from organic and integrated strawberry farms.

	P	K	Mg	Fe	Cu	Zn	Mn	Antioxidant activity
Production system (P)	**	**	**	**	**	**	**	**
Cultivar (C)	**	**	**	**	**	ns	**	**
P × C	ns	**	**	*	**	ns	**	**
Mean value (mg kg^{-1} FW; µmol TE g^{-1} FW)								
Production system								
Organic	225 ± 14b	1108 ± 118b	97 ± 6b	2.19 ± 0.20b	0.36 ± 0.01a	0.99 ± 0.04b	1.28 ± 0.16b	55.4 ± 3.3a
Integrated	262 ± 13a	1520 ± 75a	119 ± 3a	2.51 ± 0.08a	0.29 ± 0.02b	1.19 ± 0.07a	2.11 ± 0.09a	1.28 ± 0.16b
Cultivar								
'Thuchampion'	269 ± 14a	1745 ± 60a	127 ± 1a	2.74 ± 0.11a	0.31 ± 0.05b	1.21 ± 0.07	2.15 ± 0.08a	56.2 ± 2.6b
'St. Pierre'	265 ± 21a	1217 ± 162b	107 ± 8b	2.60 ± 0.07a	0.36 ± 0.02a	1.01 ± 0.09	1.78 ± 0.32b	52.4 ± 1.8c
'Elsanta'	210 ± 19b	1172 ± 132b	100 ± 7c	2.03 ± 0.28b	0.31 ± 0.02b	1.15 ± 0.14	1.41 ± 0.20c	59.8 ± 2.7a
'Sugar Lia'	228 ± 16b	1120 ± 126c	99 ± 10c	2.03 ± 0.14b	0.32 ± 0.01b	0.98 ± 0.06	1.42 ± 0.38c	38.1 ± 0.7d

**, * Significant influence at the 0.01 and 0.05 probability levels, respectively. ns – non significant.

[a–c] Mean values (± SEM) followed by different letters within a column and particular factor are significantly different (Duncan, α = 0.05)

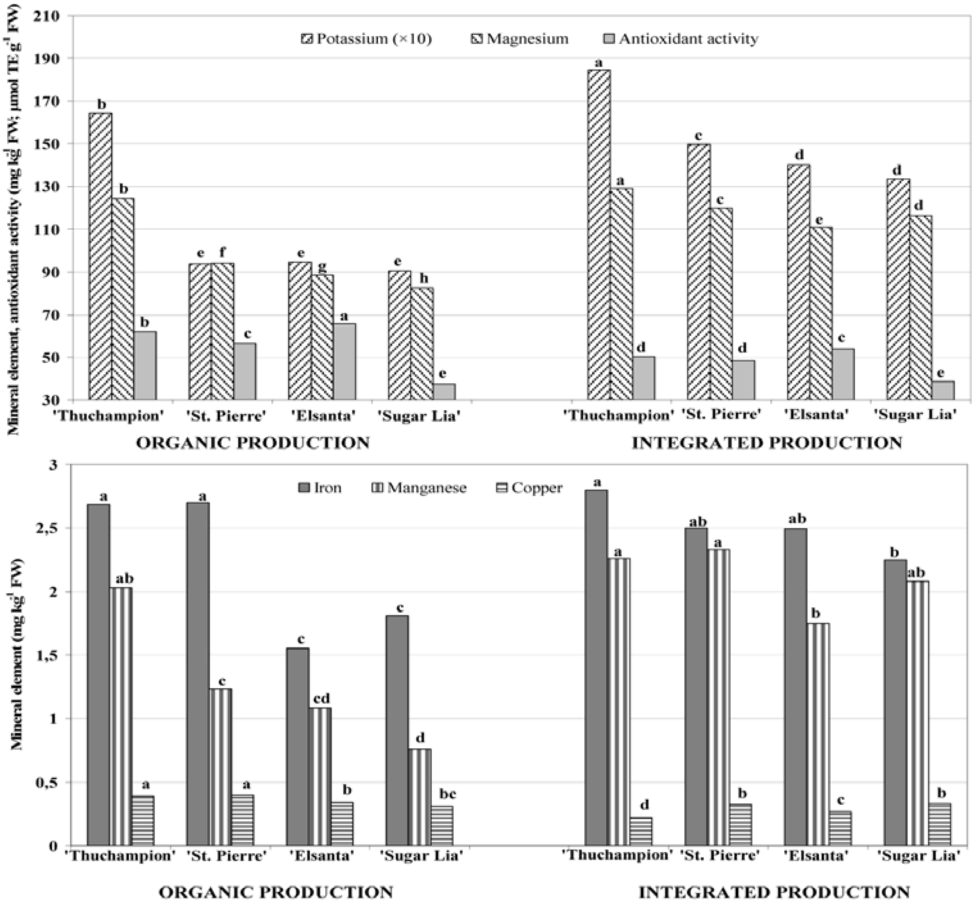

Figure 1. Mineral contents and antioxidant activities in strawberries grown under organic and integrated farming systems (interaction P × C). [a–d] Mean values (± SEM) followed by different letters are significantly different (Duncan, $\alpha = 0.05$).

4. Conclusion

The present study provides the mineral contents and antioxidant activities in fruits of four strawberry cultivars grown under OF and IFP. The mineral contents and antioxidant activities varied among the cultivars grown under the same agricultural system, except for Zn which contents obtained in all cultivars studied were not significantly different. The ranking order of cultivars in the antioxidant activity was the same regardless of agricultural practice showing that antioxidant activity is probably a cultivar-specific property. The 'Thuchampion' fruits from both systems showed the highest mineral contents, whilst 'Elsanta' has been characterized by the highest antioxidant activity. The organic strawberries showed higher antioxidant activities and Cu content, but lower contents of K, Mg, P, Fe, Zn, and Mn compared to their integrated counterparts. As the cultivars were not grown at the same location, the differences in mineral contents and antioxidant activities between cultivars were possibly overcome not only by the production system, but by the extraneous variables such as climatic variations and soil conditions. Therefore it is very difficult to draw any general conclusions on the effect of agricultural system on studied parameters.

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Povzetek

Hranilna vrednost živil postaja za potrošnike vedno bolj pomembna, zato je potrebno nameniti pozornost načinom pridelave in njihovim vplivom na vsebnost različnih hranil v živilih. Raziskovali smo vsebnost mineralov in antioksidativni potencial štirih ekološko pridelanih kultivarjev jagod »St. Pierre«, »Elsanta«, »Sugar Lia« in primerjali vrednosti z jagodami iz integrirane pridelave. Naredili smo kislinski razklop jagod in v raztopinah določili vsebnost K, Mg, Fe, Zn, Cu in Mn z atomsko absorpcijsko spektrometrijo. Vsebnost P smo določali po vanadat-molibdat metodi. Antioksidativni potencial ekstraktov jagod smo ocenili z ABTS metodo. Rezultati so pokazali, da je na vsebnost mineralov in na antioksidativni potencial vplival kultivar in način pridelave. Ekološko pridelane jagode so imele višji antioksidativni potencial in višjo vsebnost Cu, medtem ko so jagode iz integrirane pridelave vsebovale več P, K, Mg, Fe in Mn. Vsi kultivarji so imeli podobno vsebnost Zn, kar nakazuje, da njegova vsebnost v jagodah verjetno ni odvisna od kultivarja.