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Comparison of apples from organic and integrated farming

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Summary: Prima', 'Gala', 'Remo', 'Topáz', 'Idared', 'Releika', 'Resi', 'Rubinola', 'Rajka', 'Rewena' and 'Florina' apple cultivars, both from organic and integrated farming, from Pallag and Újfehértó, were compared. Average size, weight, soluble solids, titratable acidity, total polyphenols, free radical scavenging capacity expressed as Trolox equivalent (TEAC), copper and zinc were determined at harvest and after cool storage. Organic apples were more acidic, while integrated fruits had mostly higher copper and zinc content. Total polyphenols and TEAC values did not show a significant difference as a function of farming technology. A principal component analysis shows the separation of provenances as well as stored and fresh apples. Results are considered as preliminary.

Key words: organic farming, apple, antioxidant, polyphenols

Introduction

Due to food safety reasons, there is an increasing interest towards products of organic farming, At the same time there are relatively few studies collating the effect of different farming technologies. *Do Amarante* et al., (2008) compared the yield and fruit quality of apple ('Royal Gala' and 'Fuji') from conventional and organic production systems. The organic apples contained less K, Mg and N in fruits, and leaves, and fruits were smaller for both cultivars. Organic fruits of Royal Gala variety had lower acidity, but higher soluble solids. *Gonda* et al. (2000) compared some fruit quality parameters of apple cultivars in organic production to apples grown in integrated production. *Carbonaro & Mattera* (2001) found significantly higher polyphenol level and polyphenol oxidase activity in organic peaches and pears as compared to those from conventional production. As reported by *Dani* et al. (2007), organic grape juices showed statistically higher values for the total polyphenol and resveratrol content as compared to conventional ones. *Róth* et al., (2007) investigated the postharvest quality of integrated and organically produced apple fruit and found that storage conditions had a much stronger influence than the production system. *Stracke* et al., (2009) made a three-year comparison of the polyphenol contents and antioxidant capacities in organically and conventionally produced 'Golden Delicious' apple. Their main conclusion was that production method had a smaller impact on the variation in the polyphenol content and antioxidant capacity of apples than the yearly climate.

Some scientists are sceptic on the advantages of bio fruits and vegetables (*Magkos* et al. 2003, *Trewavas* 2004). In their research work *Bourn & Prescott* (2002) compared the nutritional value, sensory qualities and safety of organic and conventional foods and came to the conclusion that except with nitrate, there is no strong evidence on compositional differences.

Materials and Methods

Materials

Different apple cultivars were obtained from the Research Institute for Fruit Growing and Ornamentals, Újfehértó and the Pallag experimental field of Institute for Research and Development Centre of Agricultural Sciences and Engineering, University of Debrecen, from 2008 crop year. The tested cultivars were: 'Prima', 'Gala', 'Remo', 'Topáz', 'Idared', 'Releika', 'Resi', 'Rubinola', 'Rajka', 'Rewena' and 'Florina', both organic and integrated. The latter six cultivars were tested after storage only. Apple fruits were stored in traditional storeroom under air at Újfehértó station at 2°C and 85-95% relative humidity all the time from harvest in August-September 2008 until January 2009.

The free radical 1,1-Diphenyl-2-picrylhydrazyl (DPPH) and standard Trolox,(6-hydroxy-2,5,7,8-tetramethylcromane-2-carboxylic acid) were obtained from Fluka (Buchs, Switzerland) Other reagents were of analytical grade and purchased from Reanal (Budapest, Hungary).

Methods used

Apples were washed, size and weight of 30 fruits was measured according to Hungarian Standard MSZ 967-1:1982. From approximately five kg of sample one kg optimally ripened, sound fruit was selected and disintegrated unpeeled using a Waring blender. The blended fruit sample was used in the different tests and analyses.

Soluble solids were measured from pressed apple juice with an Abbe refractometer (Carl Zeiss, Jena) according to Hungarian Standard MSZ EN 12143 at 20°C.

Titratable acidity was determined according to MSZ EN 12147 from 10 grams of fruit pulp by an automatic titrator (Mettler DL 70). Results obtained at pH 8.1 are expressed as citric acid equivalent.

Polyphenols were measured after 80% methanol extraction of fruits. Twenty ml of methanol was added to 5 g fruit pulp and incubated overnight at 4°C. After sonication, the sample was filtered and subjected to colour reaction with Folin-Ciocalteu reagent, which was performed according to MSZ 9474:1980 and given as gallic acid equivalent (GAE).

The free radical scavenging activity (antioxidant capacity) was determined by DPPH method. The DPPH free radical scavenging assay was performed according to the method reported by *Brand-Williams* et al. (1995) with some modification. Fifty L of methanolic extract of sample or methanol (control) were added to two ml of methanol solution of a 100 µM DPPH. Liquid in the cuvette was mixed and left to stand in a thermostated spectrophotometer in the dark at 36°C for 30 min and absorbance was then read at 517 nm using a Unicam spectrophotometer. Antiradical activity was expressed in mmol/kg using a Trolox calibration curve.

Copper and zinc were determined with atomic absorption spectrometry with flame ionisation mode (AAS) according to AOAC 975-03 (1990). Five g of the blended fruit were digested with a mixture of HNO_3-$HClO_4$-H_2SO_4 (30:1:5) acids. Measurement was carried out using Solaar M5 AA spectrometer (Thermo Elemental). Measurement conditions are summarized in *Table 1.*

The values are given as means and standard deviation of triplicate samples. Principal component analysis was performed using Minitab software version 13,0.

Results and Discussion

The results from literature indicated that the probable difference between apples from organic and integrated farming is smaller than between organic and conventional ones.

Table 1. Measurement conditions

Element	Technique	Wavelength
Copper	STAT accessory, absorption	324,8 nm
Zinc	absorption	213,9 nm

Basing on the fact that apple is not nitrate accumulating fruit in this work nitrate (expected to be under 5 mg/kg) was disregarded among different measurements, although. *Bourn & Prescott* (2002) accentuated nitrate as the main difference in foods from diverse farming systems including organic and conventional.

The fruit size and weight are summarized in *Table 2*, while results obtained by chemical analyses for the different parameters with standard deviations are shown in *Table 3*. All values were calculated in proportion to the fresh weight.

Table 2. Size and weight of apples at harvest and after storage

Cultivar	Date and provenance	Average size	greatest	smallest	average weight per piece
		cm	cm	cm	g
at harvest					
Príma bio	VIII.21. Újfehértó	7.55	8.59	6.81	154.5
Príma integrated	VIII.21. Újfehértó	7.53	8.71	6.52	165.2
Gala bio	VIII. 21. Pallag	6.79	7.45	5.25	134.8
Gala integrated	VIII. 21. Pallag	7.31	8.04	6.05	167.4
Remo bio	IX.1. Újfehértó	7.29	8.19	6.02	158
Remo integrated	IX.8. Újfehértó	6.46	7.24	5.92	110
Remo bio	IX.29. Pallag	6.17	7.30	4.72	99
Remo integrated	IX.29. Pallag	7.66	8.91	6.52	174
Topáz bio	IX.25. Újfehértó	7.58	8.39	6.79	164
Topáz integrated	IX.29 Újfehértó	7.14	8.65	6.33	145
Idared bio	IX.29. Pallag	7.74	9.18	6.81	185
Idared integrated	IX.29. Pallag	7.88	8.88	6.22	196
after storage					
Príma bio	VIII.19. Újfehértó	7.63	8.27	7.27	150
Príma integrated	VIII.21 Újfehértó	8.02	8.59	7.17	173
Releika bio	IX.01. Újfehértó	6.23	6.93	5.52	96
Releika integrated	IX.02. Újfehértó	5.43	5.79	5.06	70
Resi bio	IX.01. Újfehértó	5.87	6.57	5.18	82
Resi integrated	IX.02. Újfehértó	5.43	6.05	5.09	68
Remo bio	IX.01. Újfehértó	7.67	8.12	7.11	170
Remo integrated	IX.08. Újfehértó	6.44	7.12	5.61	109
Rubinola bio	IX.03. Újfehértó	7.77	8.22	6.77	174
Rubinola integrated	IX.08. Újfehértó	7.12	7.84	6.38	133
Rajka bio	IX.08. Újfehértó	7.62	8.26	7.10	181
Rajka integrated	IX.23. Újfehértó	6.46	6.83	6.05	108
Rewena bio	IX.19. Újfehértó	6.85	7.83	6.24	141
Rewena integrated	IX.19. Újfehértó	6.26	6.88	5.67	112
Topaz bio	IX.25. Újfehértó	7.58	8.21	6.52	166
Topaz integrated	X.01. Újfehértó	7.16	7.88	6.84	141
Florina bio	IX.25. Újfehértó	6.96	7.50	6.37	148
Florina integrated	X.1. Újfehértó	7.56	8.13	6.84	181

Table 3. Composition of apples at harvest and after storage

Cultivar	Date, provenance	Brix	Titratable acidity pH 8.1 as CA		Polyphenols (GAE)		TEAC		Copper		Zinc	
		degree	g/kg	g/kg	mg/kg	mg/kg	mmol/kg	mmol/kg	mg/kg	mg/kg	mg/kg	mg/kg
			avg	st.dev.	avg	st.dev.	avg	st.dev.	avg	st.dev.	avg	st.dev.
Príma bio	VIII.21. Újfehértó	11.2	4.68	0.01	586	50	4.3	0.1	0.191	0.010	0.16	0.001
Príma integrated	VIII.21. Újfehértó	12	4.68	0.03	484	90	3.5	0.2	0.501	0.015	0.109	0.005
Gala bio	VIII. 21. Pallag	12.2	2.61	0.01	436	60	3.7	0.1	0.247	0.018	0.084	0.015
Gala integrated	VIII. 21. Pallag	12	2.35	0.02	392	18	3.5	0.2	0.179	0.008	0.11	0.005
Remo bio	IX.1. Újfehértó	14	7.79	0.12	242	3	2.1	0	0.151	0.001	0.228	0.008
Remo integrated	IX.8. Újfehértó	12.6	6.58	0.07	258	1	2.1	0.2	0.352	0.012	0.228	0.006
Remo bio	IX.29. Pallag	15.5	6.7	0.08	657	24	2.8	0.1	0.433	0.004	0.237	0.02
Remo integrated	IX.29. Pallag	14	5.4	0.04	504	55	3	0.1	0.198	0.011	0.208	0.02
Topáz bio	IX.25. Újfehértó	13.3	5.32	0.03	701	22	4.2	0.2	0.223	0.026	0.149	0.013
Topáz integrated	IX.29 Újfehértó	13.4	4.89	0.01	513	12	3.2	0.4	0.387	0.014	0.205	0.008
Idared bio	IX.29. Pallag	12.3	5.06	0.01	409	31	2.7	0.1	0.186	0.013	0.043	0.008
Idared integrated	IX.29. Pallag	13.6	6.4	0.04	460	51	2.9	0.3	0.245	0.014	0.046	0.005
Príma bio	VIII.19. Újfehértó	9.3	3.16	0.05	419	17	1.9	0	0.180	0.0004	0.255	0.0026
Príma integrated	VIII.21 Újfehértó	10.3	3.16	0.1	459	74	2.4	0.1	0.486	0.004	0.231	0.0012
Releika bio	IX.01. Újfehértó	13.4	2.84	0.1	718	72	4.1	0.1	0.204	0.0038	0.213	0.0021
Releika integrated	IX.02. Újfehértó	11.8	1.64	0.03	684	32	3.6	0.3	0.567	0.0068	0.313	0.009
Resi bio	IX.01. Újfehértó	12.2	2.84	0.06	496	66	2.4	0	0.093	0.008	0.133	0.002
Resi integrated	IX.02. Újfehértó	10.6	1.51	0.08	544	28	2.4	0.2	0.338	0.0017	0.256	0.005
Remo bio	IX.01. Újfehértó	13.3	5.28	0.08	308	15	1.9	0.1	0.201	0.009	0.139	0.0022
Remo integrated	IX.08.Újfehértó	11.3	3.43	0.07	253	20	1.5	0.2	0.431	0.0038	0.233	0.0019
Rubinola bio	IX.03.Újfehértó	13	3.78	0.06	824	75	4.9	0.2	*0.250*	0.004	0.172	0.0034
Rubinola integrated	IX.08.Újfehértó	12.5	2.05	0.07	791	17	5.2	0.3	*0.592*	0.009	0.289	0.0014
Rajka bio	IX.08.Újfehértó	13.6	2.61	0.08	856	82	4.3	0	0.223	0.0058	0.218	0.0023
Rajka integrated	IX.23. Újfehértó	10.4	1.96	0.05	644	51	3.7	0.2	0.392	0.0016	0.265	0.0046
Rewena bio	IX.19. Újfehértó	12.4	5.18	0.08	508	21	2.2	0.3	0.168	0.006	0.247	0.0015
Rewena integrated	IX.19. Újfehértó	12.5	2.77	0.07	519	19	3	0.2	0.285	0.0068	0.288	0.0009
Topaz bio	IX.25. Újfehértó	12.4	4.89	0.09	706	25	3.8	0.3	0.214	0.008	0.148	0.0010
Topaz integrated	X.01. Újfehértó	11.6	3.21	0.04	691	82	3.4	0.3	0.300	0.011	0.213	0.0015
Florina bio	IX.25. Újfehértó	10.6	2.36	0.06	523	23	3.1	0.1	0.295	0.0005	0.396	0.0016
Florina integrated	X.1. Újfehértó	13.2	1.89	0.08	566	26	4.4	0.1	0.199	0.0004	0.396	0.0011

The highest level of total titratable acidity was found in bio apples, 13 cases from the 15 bio-integrated sample pairs. In contrast to our results, *do Amarante* et al., (2008) found lower acidity with organic apple cultivar ‘Royal Gala’, while *Róth* et al., (2007) measured uniform acidity in organic and integrated ‘Jonagold’ apples at harvest and during storage. Difference in acid content may be due to different ripening stages at harvest.

The total polyphenol content did not differ significantly in organic and integrated sample pairs. The polyphenol level is also expected to strongly be influenced by ripeness.

The heavy metal content of integrated samples was mostly higher. From the 15 bio-integrated pairs, 12 and 10 apple cultivars contained higher level of copper and zinc respectively.

A 4-month storage caused a loss of 12% (in Topáz, organic) and 49% (in Remo, integrated) in titratable acidity, with integrated fruits losing higher amounts of malic acid. Because of the small number of sample pairs, so far, available for analysis, this needs further investigation for more clarification. Not agreeing with our results, *Róth* et al., (2007) did not find any difference between organic and integrated apples in the acid loss of at the end of shelf-life (six months) neither in air storage nor in controlled atmosphere. The acid loss measured by them was much higher (above 40%) in air storage than under controlled atmosphere.

Water soluble solids (Brix degree) decreased by 0.7–1.8 degree as a function of storage. This finding is also not agreeing with what *Róth* et al. (2007) observed. There are opposite processes influencing water soluble solids: While weight loss causes a concentration, dissimilation consumes sugars.

Polyphenols and free radical scavenging activity have also fallen during storage, but not significantly. The differences were in the range of measurement uncertainty.

The dataset for bio and integrated cultivar pairs were compared by principal component analysis based on correlation matrix. Fruit size and fruit weight were not included in PCA. According to the loading plot, (*Figure 1*) the first component is connected with the titratable acidity and concentration of copper and zinc, while the second factor is composed by antioxidant capacity, polyphenolics and soluble solids. First two principal components explain 63% of the variability in the data.

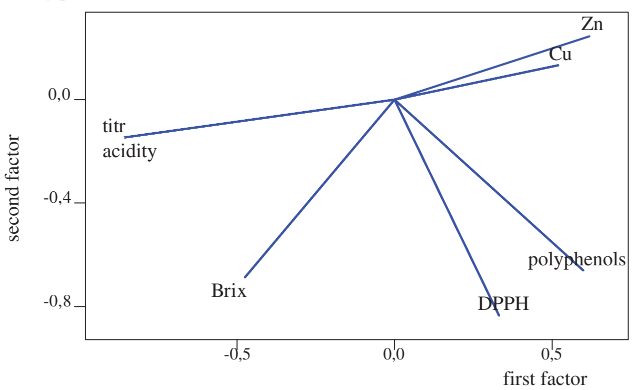

Figure 1. Principal component analysis, loading plot of apple data

The samples from Pallag and Ujfehértó region are separated on principal analysis score plot, (*Figure 2*) and a separation is observable between the fresh and stored apples because of the lower acidity of stored fruits.

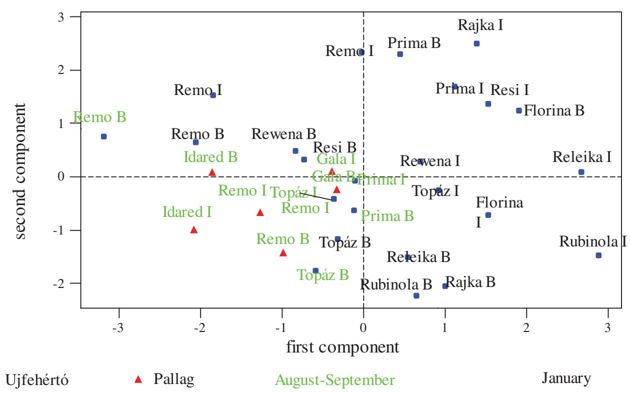

Figure 2. Principal component analysis, score plot of apple data

These results are considered as preliminary, as the experiment is continued in 2009–2010 season.

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