Original Article

Influence of climatic conditions on nutritional and nutraceutical profiles of organic-grown sweet red-peppers (*Capsicum annuum* L.)

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Summary. This research showed the evaluation of some quality parameters in two red-pepper genotypes named "Alceste" and "RS08" cultivated with organic system in two seasons, on 2010 and 2011, in 11 years organic-converted soils. All samples, harvested at commercial ripening, have been subjected to some quality aspects as follows. Nutritional quality: soluble sugars, pyrazine volatile compounds. Nutraceutical quality: ascorbic acid, polyphenols, carotenoids and antiradical capacity. The attention was particularly focused on pyrazines (2-methoxy-3-isopropyl pyrazine and 2-methoxy-3-isobutyl pyrazine), for their interesting odorous properties. Moreover, the antioxidant profile (mainly ascorbic acid and carotenoids) was examined for its role in the nitrosamine inhibition, that is responsible of some tumors. The main finding was a clear difference in both genotypes in the behavior of phytochemicals: pyrazine increased in 2011 with respect to 2010, while sugars and the nutraceutical profiles clearly depleted. The antiradical capacity, measured by DPPH*, was well correlated with phytochemical amounts, also showing the same decreasing trend in 2011. This behavior can be depended on the different climate conditions in the two years, particularly in the period August-September of 2011. Besides, the plant stress was evidenced in 2011 also by a significantly decreased productivity.

Key words: Pyrazines, soluble sugars, vitamin C, carotenoids, polyphenols, antiradical activity, GC/MS and HPLC analysis

«Influenza delle condizioni climatiche sui profili nutrizionali e nutraceutici di peperoni rossi dolci (*Capsicum Annuum* L.) coltivati in biologico»

Riassunto. Questa ricerca ha studiato alcuni parametri qualitativi di due genotipi di peperone rosso dolce (cv. Alceste e cv. RS08), coltivati per due anni (2010-2011) in un terreno convertito alla coltivazione biologica da almeno 11 anni. Tutti i campioni, raccolti al giusto grado di maturazione commerciale, sono stati sottoposti alla valutazione dei seguenti parametri qualitativi. Qualità nutrizionale: zuccheri solubili e composti volatili caratteristici, come le pirazine. Qualità nutraceutica: acido ascorbico, polifenoli, carotenoidi e capacità antiradicalica. La nostra attenzione era particolarmente rivolta alle pirazine (2-metossi-3-isopropil pirazina e 2-metossi-3-isobutil pirazina) per il loro intenso e caratteristico odore che impartiscono all'aroma di peperone. Inoltre, sono stati esaminati i profili degli antiossidanti (principalmente acido ascorbico e carotenoidi) per il loro ruolo nella inibizione delle nitrosammine, che sono responsabili di alcune forme tumorali. I dati

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ottenuti hanno messo in evidenza che in ambedue i genotipi le pirazine aumentavano nel 2011 rispetto al 2010; mentre gli zuccheri solubili e le sostanze nutraceutiche prese in esame diminuivano in modo molto evidente nel 2011. La capacità antiradicalica, misurata mediante il DPPH*, presentava una buona correlazione con i profili nutraceutici, mostrando anche essa un decremento nel 2011 per ambedue i genotipi di peperone. Questo comportamento potrebbe dipendere dalle differenti condizioni climatiche verificatesi nei due anni di sperimentazione, in particolare nel periodo agosto-settembre 2011. Inoltre, lo stress subito dalle piante era evidenziato nel 2011 anche da una significativa diminuzione della produttività per ambedue i genotipi.

Parole chiave: Pirazine, zuccheri solubili, vitamina C, carotenoidi, polifenoli, attività antiradicalica, analisi GC/MS ed HPLC

Introduction

Many studies have focused the potential antitumor effects of sweet peppers. Pepper extracts, in fact, have inhibited the formation and/or the activity of some carcinogenic substances, such as nitrosamines. Ramirez-Victoria et al. (1) demonstrated antimutagenic effect of pepper extracts against the nitrosation process using the somatic mutation and recombination test in wing cells of *Drosophila melonogaster*. While, Gonzales de Meja et al. (2) evidenced in *Salmolella typhimurium* the antimutagenic action of carotenoids extracts from five different types of pepper against 1,6-dinitropyrene and 1,8-dinitropyrene. Moreover, other studies pointed out that the pepper and other fruits and vegetables (kiwi, garlic, onion, etc.) consumption could reduce the risk of brain tumour, probably due to their action on nitrosamines. In fact Ikken et al. observed by Ames test that the alcoholic extracts of pepper and other vegetables had an antimutagenic effect against different nitrosamines (3). These clear biological actions are probably due to some antioxidant and antiradical substances contained in pepper, such as vitamin C, carotenoids and polyphenols, that could explain the above cited findings. But further researches are necessary to better identify the active molecules and deepen their action mechanisms.

Buttery et al. (4) and Buchbauer et al. (5) have studied the volatile composition of green and sweet pepper by solvent extraction and GC/MS quali-quantitative analysis. They identified a series of compounds classes as alcohols, aldehydes, chetones and terpenes. But their attention was particularly focused on pyrazines for their interesting odour properties.

The aim of this research is the evaluation of nutritional and nutraceutical properties of two organic red-pepper genotypes named "Alceste", a commercial cv, and "RS08", a selected landrace typical cv. from Marche region.

Experimental part

All genotypes were cultivated over two seasons, on 2010 and 2011 in 11 years organic-converted soils, located in the experimental field of CRA-ORA (Monsampolo del Tronto, AP, Italy). The samples, harvested at commercial ripening, have been subjected to some quality aspects, performed at CRA-IAA, Milan (Italy), as follows. *Nutritional quality:* soluble sugars by HPLC (6), pyrazine volatile compounds (2-methoxy-3-isopropyl pyrazine and 2-methoxy-3-isobutyl pyrazine) by GC/MS (7). *Nutraceutical quality:* ascorbic acid by HPLC (8), total polyphenols index (Folin reaction) (9), carotenoids by spectrophotometric analysis (10) and antiradical capacity by DPPH* scavenging assay (11). The analysis were performed in triplicate for each sample. The Tukey's test was used to evaluate the differences of quality parameters between two pepper genotypes. Mean values were considered significantly different when $\rho \leq 0.05$.

Results and discussion

Nutritional quality

In Table 1, the composition of the pyrazines, identified during two years of experimentation in two organically cultivated genotypes, were reported. In Alceste genotype, there was an increase of 31% of total pyrazines in 2011 with respect to 2010. The same behaviour was showed by RS08, where the increase was of 53% in 2011 in comparison with 2010.

Table 1. Nutritional quality of organic red-pepper in two seasons. Different letters indicate statistically significant differences (ρ≤0,05) between the two seasons within the same genotype.

	ALCESTE			RS08		
	2010	2011	% Change 2011 VS 2010	2010	2011	% Change 2011 VS 2010
2-methoxy-3-isopropyl pyrazine (μg/100 g d.w.)	15,95 a	18,38 a	+15,23	9,35 a	14,81 b	+58,39
2-methoxy-3-isobutyl pyrazine (μg/100 g d.w.)	7,14 a	11,80 b	+65.26	22,23 a	33,43 b	+50,38
Total pyrazines	23,08 a	30,18 b	+30,76	31,58 a	48,24 b	+52,75
Glucose (g/100 g f.w.)	2,90 b	2,44 a	-15,86	2,93 b	2,14 a	-26,96
Fructose (g/100 g f.w.)	2,93b	2,33 a	-20,47	2,62 b	2,09 a	-20,23
Total soluble sugars	5,83 b	4,77 a	-18,18	5,55 b	4,23 a	-23,78

Table 2. Nutraceutical quality of organic red-pepper genotypes in two seasons. Different letters indicate statistically significant differences (ρ≤0,05) between the two seasons within the same genotype.

	ALCESTE			RS08		
	2010	2011	% Change 2011 vs 2010	2010	2011	% Change 2011 vs 2010
Ascorbic acid (mg/100 g f.w.)	151,78 a	145,63 a	-4,05	179,56 b	151,56 a	-15,59
Total Carotenoids (mg/100 g f.w.)	13,94 b	8,62 a	-38,16	15,97 b	12,91 a	-19,16
Polyphenols (mg/100 g f.w.)	72,48 b	40,55 a	-44,05	52,32 b	30,91 a	-40,92
Antioxidant capacity (DPPH* mg						
Trolox eq./100 g f.w.)	3,57 b	2,16 a	-39,77	3,05 b	2,39 a	-21,64

On the contrary, the soluble sugars decreased in 2011 of 18% in Alceste and 24% in RS08, with respect to 2010.

Nutraceutical quality

Table 2 showed the nutraceutical parameters of two organically grown sweet pepper. In Alceste genotype, ascorbic acid had a not statistically significant decrease in 2011(4%); while this trend was more evident in RS08 (-16%).

Total carotenoids and total polyphenols decreased in both genotypes during 2011; this loss was more noticeable in Alceste (38% and 44%, respectively), while in RS08 the decrease resulted of 19% and 41%, respectively.

The antiradical power, measured with DPPH* method, of both genotypes decreased in 2011, probably due to a lower content of nutraceutical compounds in 2011 samples, 40% decrease in Alceste and 22% in RS08.

From experimental data, it can be deduced that in both organically grown genotypes, the pyrazines

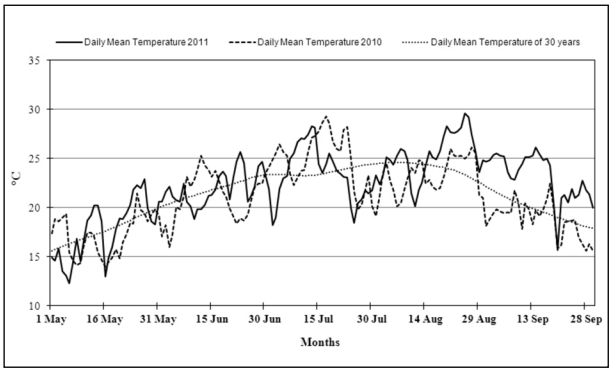

Figure 1. Daily mean temperature of 2011, 2010 and of the last 30 years. Data detected by CRA-CMA weather station (Rome, Italy).

content increased, while soluble sugars and nutraceutical profiles depleted during the second year of experimentation. This behaviour could be depended on the different climate conditions in the two years. In the period August-September of 2011 the rainfall was significantly lower and the average daily temperature was increased by about 5°C, with respect to 2010 (Fig. 1 and 2). The plant stress was evidenced in 2011 also

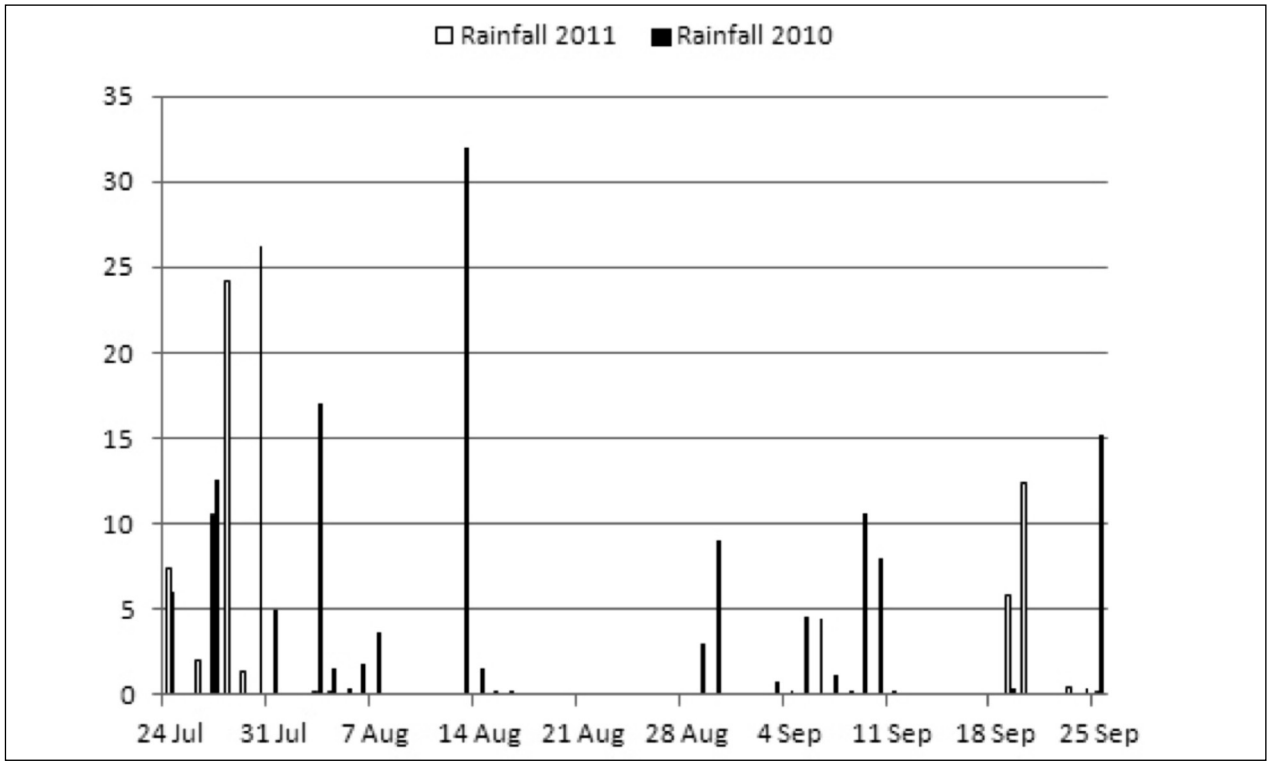

Figure 2. Rainfall of 2011 and 2010. Data detected by CRA-CMA weather station (Rome, Italy).

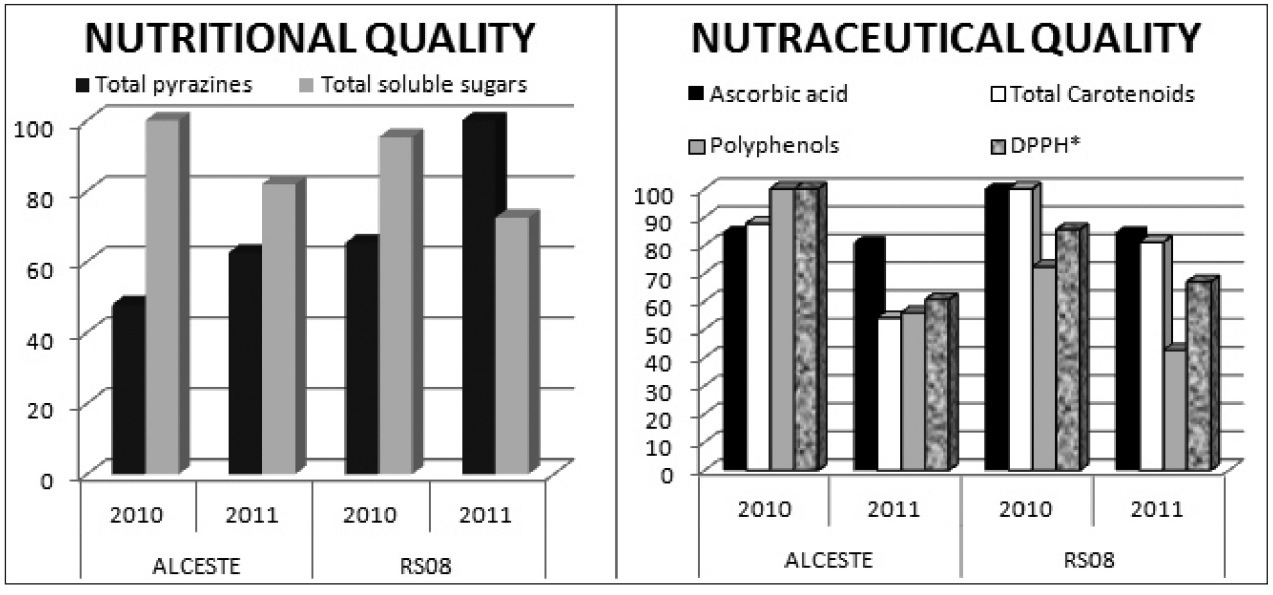

Figure 3. Comparison of nutritional and nutraceutical parameters of Alceste and RS08 genotypes, where the highest values of each parameters is= 100%

by a significantly decreased productivity (1,50 kg/plant in 2011 vs. 2,61 kg/plant in 2010 for Alceste and 1.82 kg/plant in 2011 vs 2.42 kg/plant in 2010 for RS08).

Conclusions

The evaluation of nutraceutical and nutritional quality (Fig. 3) of two organically grown sweet pepper genotypes, highlights that the effects of pedo-climatic conditions during these two years of experiments are very evident within the two assayed varieties, having exactly the same effect in every considered parameter. Consequently, the chemical and nutraceutical parameters and productivity are different in the two years of experimentation.

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