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Organic and conventional vegetables: Comparison of the physical and chemical characteristics and antioxidant activity

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The objective of this research was to compare the physical and chemical characteristics and antioxidant activity of organic and conventional carrot (*Daucus carota*), green pepper (*Capsicum annuum*) and lettuce (*Lactuca sativa*). Five representative samples of conventional vegetables, certified organic and non-certified organic vegetables were gotten from farms and supermarkets in the city of Rio de Janeiro. The result shows that the organic carrot showed higher acidity (0.11 g % citric acid) and total sugar (5.68 g %) than those found in standard samples and certified organic ones ($p<0.05$). Regarding the density analysis and total soluble solids, there was no statistical difference between carrots, green peppers and lettuce from all types ($p>0.05$). It was observed that the vitamin C levels in carrot samples levels had no significant difference between the different forms of production ($p>0.05$). Conventional lettuce and certified organic pepper showed higher vitamin C than the other samples ($p<0.05$). The antioxidant activity of the samples was analysed by the capacity to reduce the DPPH (1,1-diphenyl-2-picryl- hydrazyl) radical, in which carrot and conventional pepper showed lower antioxidant activity ($p<0.05$) when compared to organic samples. There were no significant differences among the different forms of production in the lettuce samples ($p>0.05$). Carrot and green pepper, with seal certification or not, showed higher capacity to reduce DPPH than the conventional ones, this suggests that the form of cultivation has a direct relationship with the nutritional values of the vegetables.

Key words: Carrot, lettuce, green pepper; organic, conventional, antioxidant activity, physico-chemical analysis.

INTRODUCTION

Some diseases such as hypertension, cardiovascular disease and stroke could be prevented by a regular daily consumption of fruits and vegetables (WHO, 2004). Composite diets such as DASH diets and the Mediterranean diet, being rich in fruits, vegetables but with reduced fat content, have been associated with the

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reduced risk of developing these diseases (Reddy et al., 2004; Gulçin, 2012). The role of antioxidants in the prevention of various chronic diseases, delaying and inhibiting the oxidation of lipids and other molecules has been an established fact. They neutralize free radicals and thereby prevent many non-communicable diseases such as cancer, diabetes and cardiovascular diseases. Fruits and vegetables are good sources of hydroxylase aromatic compounds called polyphenols plants (Pandey and Rizvi, 2009; Cartea et al., 2011). Besides, there are many herbs and spices that are also a rich source of antioxidants (Waman and Karanjalker, 2010) and play pivotal role in the prevention of such diseases.

Production of vegetables may be performed by adopting different systems (Mattheis and Fellman, 1999). The conventional system is characterized by a high use of chemical pesticides, in which the use of these inputs is justified in order to increase productivity, quality and resistance to pests and diseases (Aktar et al., 2009; Oates and Cohen, 2009). Possible toxic effects in humans are related to the use of pesticides in conventional agriculture (Brouwer et al*.,* 1999). These products have in their composition hundreds of active ingredients that are linked to those effects (Kopke, 2000). In the conventional system, when the technical recomendations are not followed appropriately, it can endanger humans health and contaminate the environment.

Organic production entails growing of crops without synthetic pesticides and should be produced from organisms that have not been genetically modified or have undergone ionizing radiation (Ferreira et al., 2015). Moreover, it should use sustainable practices to enable the reduction of contamination and degradation of th soil, water and air (Dangour et al., 2009). Organic producers utilize a wide range of alternative inputs and cultural practices for managing the cultures in a manner believed to be safer for the environment and better for the consumer (Amodio et al., 2007; Knap et al., 2014).

The organic system is an alternative, but is considered to be more expensive than the conventional (Engindeniz and Tuzel, 2006). From the moment that producers begin to produce more organic foods and become more accustomed to this type of production the tendency is that these foods become cheaper. Then the cost can be reduced even more over time with increase in production scale and the organization of these producers. The certification of organic products can be made internationally or nationally and is recognized in the market with an organic certification seal. Organic food produced against the standards of the country, where the product is sold is identified as fraud (FAO, 2009).

Antioxidant activity has been reported to increase due to cultivation following organic methods, as such crops are known to produce higher amounts of protective substances, such as polyphenols, etc. A study by Castro et al. (2014) showed that plants grown on organic system were more exposed to the environment and had higher antioxidant capacity. Another study by Roghelia and Patel (2015) concluded that antioxidant potential, flavonoid and total phenol levels were higher in the system without fertilizers as against the conventional system. The connection between plant stress levels and the production of secondary metabolites, including many polyphenols and antioxidants, it is justified because relatively higher levels of antioxidant are produced by plants in response to stress and pest attack (Benbrook, 2005). A study by Dumas et al. (2003) still reports that inorganic fertilizer reduce the antioxidant levels, while organic fertilizer has been proven to enhance antioxidant content in plants. In addition, modifications caused by the use of highly toxic soluble chemical fertilizers and agricultural chemicals can cause imbalances in food and reduce protein production or increase the degradation of these substances.

Some agricultural practices increase the emissions of gases such as frequent interventions, mineral fertilization and intensive tillage. Müller-Lindenlauf (2009), in FAO report, analyzed the possibilities of organic farming be considered a significant activity for carbon sequestration. The carbon is one of those responsible for greenhouse gases and the high level of carbon capture in organic production systems contribute to the increase of carbon stock in soil and biomass United Nations, 2003). Pelletier et al. (2008) also showed that the production system without fertilizer generated lower emissions than the conventional production, mainly involving use of nitrogen fertilizers in conventional farming. Furthermore, the yield and power consumption of an organic production is nearly the same as that of conventional production.

Organic production has been discussed and evaluated in the modern world as an alternative to the conventional way, being characterized as adequate for health and capable of reducing environmental degradation. Due to increased consumer interest in organic food, it becomes necessary to know, based on scientific studies, the quality of the different organic systems. The present study concerned comparison of the physical and chemical characteristics and antioxidant capacity of organic and conventional carrot, green pepper and lettuce.

MATERIALS AND METHODS

Samples

Samples of carrot (*Daucus carota*), green pepper (*Capsicum annuum*) and smooth lettuce (*Lactuca sativa*) were purchased from the supermarkets and farmer's markets in Rio de Janeiro, Brazil. The carrot samples were analyzed between August and December 2012, the green pepper from January to April 2013 and the lettuce between April and July 2013. Initially, a survey was conducted to identify producers of the organic vegetables and the establishments that sell them. The vegetables were chosen based on a survey of commercial establishments in the city of Rio de Janeiro, which sell organic food. The carrot along with lettuce and green pepper were the most found organic vegetables on the areas surveyed. Therefore these foods were chosen for comparison of their physical and chemical characteristics and antioxidant activity. All samples were obtained according to their similar sensorial characteristics (appearance, color and texture), including the conventional ones. The vegetables were purchased and immediately analyzed in the Laboratory of Nutritional Biochemistry at the Federal University of the State of Rio de Janeiro, in Brazil.

Sample preparation

The samples were washed in tap water to eliminate any surface contaminants. Analysis of vitamin C and antioxidant activity were made immediately after the acquisition of the products, to avoid any changes in these characteristics. Approximately 300 g of each products were put in a comercial juice extractor (Samson GB- 9001, Greenbison Inc., USA) to obtain a more liquid extract to be used subsequently in all analyses. Fluid extract was stored in the refrigerator (5°C) and other analyses were made five days after purchase. Five representative samples for each vegetables (certified organic, non-certificate organic and conventional) were obtained and analyzed *in triplicate*.

Quality parameters

The reducing sugars analysis was performed using 20 ml of the sample, which was first heated to 90°C followed by acid hydrolysis. For this, 1 ml of concentrated HCl was added and it was maintained in a water bath for 30 min. The mixture was removed, cooled at room temperature and neutralized using sodium hydroxide (40%). The mixture was transferred to a 100 ml volumetric flask and volume was made up to 100 ml using distilled water (Institute Adolfo Lutz, 2008).

The total soluble solids analysis was performed by reading the refractometer at 25°C, in which three drops of juice from each sample were placed and the results were expressed in °Brix. The density was analyzed with the use of pycnometer at 25°C. The titratable acidity was determined by a neutralization titration with 0.01 N NaOH using a phenolphthalein indicator (pH 8.1 to 10.0). The volume of the NaOH used in the analysis was measured after the color change. The total acidity was expressed as citric acid (Institute Adolfo Lutz, 2008).

N-Bromosuccamide method (NBS) was used to determine the amount of ascorbic acid (vitamin C) in the samples. The sample was weighed (10 g) and transferred to 100 ml volumetric flask. This mixture was transferred to an Erlenmeyer flask to which was added 10 ml oxalic acid, 4 ml KI (potassium iodide) and drops of starch. Then it was titrated with NBS solution to form a blue color, indicating signal the end point. The results were expressed in g/100 g of citric acid (Institute Adolfo Lutz, 2008).

Total antioxidant capacity of 2,2-diphenyl-1-picrylhydrazyl (DPPH)

The DPPH (2,2-diphenyl-hydrazyl 1-picryl-) analysis was performed following the method described by Brand-Williams et al. (1995) and modified by Miliauskas et al. (2004). In test tubes, the extracts of the samples (5, 10, 15 and 25 μL) and 3 ml of methanol solution of DPPH were placed and left to stand for half an hour. Using a spectrophotometer (Sequoia - Turner^{TM} 340) absorbance was recorded at 515 nm. The antioxidant capacity was expressed as percentage of DPPH consumed, calculated according to the following expression:

% consumed = (Control absorbance – Sample absorbance) × 100 / Control absorbance

The results were expressed as IC_{50} which is the concentration of the sample required to reduce 50% of the radical DPPH.

Phenolics

The Folin-Ciocalteu assay (FCR) is one of the oldest methods of quantification of phenols in a sample therefore also known as total phenols assay. Through the spectrophotometric method it was possible to perform the analysis of phenolic compounds (Singleton et al., 1999). Three solutions were prepared: 10ml Folin-Ciocalteau (10%) and water; 0,1g gallic acid and water; 20 g sodium carbonate (4%) and water. In a thermostat the samples were placed and then the absorbance was read using a spectrophotometer at λ^{max} = 750 nm. For the analysis were used three extractors: methanol 70% (M), ethanol 70% (E) and water (W). For each extractor were dissolved five grams of sample (5 g of sample + 15 ml of extractor). This was then filtered through a filter paper and 25 ml of sample were transferred to a volumetric flask and it was completed with the respective extractor. Gallic acid solution was subjected to the same process and calibration curve was obtained. By the absorbance the concentration of phenolics was read (mg/ml) from this line and the phenolics content in extracts was expressed in gallic acid equivalent (mg GAE/100 g).

Statistical analysis

Results were expressed as means ± SD and all the analysis were perfomed *in triplicate*. The results were submitted to analysis of variance (ANOVA) and the means were seperated by Tukey's test at 5% probability, using the GraphPadPrism 4.0 and Statistical 6.0. Differences were considered significant when $p < 0.05$ and not significant when $p > 0.05$. In addition, a correlation was taken between the antioxidant capacity, phenolic compounds and vitamin C through the same statistic program.

RESULTS AND DISCUSSION

Physico-chemical analysis

Carrot (*Daucus carota*)

The results of total acidity were 0.08 ± 0.00 g% for conventional samples, 0.08 ± 0.00 for organic certified and 0.11 ± 0.34 g% for organic samples, so organic carrot presented values higher than organic certified and conventional ($p < 0.05$). The Nutrition and Public Health Intervention Research Unit London School of Hygiene and Tropical Medicine (July, 2009) conducted a review of studies in which those with classified as satisfactory analysis showed a higher titratable acidity in organic crops, that goes with this present study and confirm the results (Table 1).

Soluble solids (°Brix) did not differ significantly in all samples. These results agree with Bender et al. (2009) in which the contents of soluble solids was the same among carrots cultivation systems. Total sugar content in carrot of organic non-certified and organic with seal showed significantly higher mean values, when compared with conventional ones. The same result was found in the study by Rembialkovska and Hallmann (2007).

The values of density and ascorbic acid were not

Table 1. Physico-chemical analysis of conventional and organically grown of carrot (*Daucus carota*).

Parameter	Sample	Acidity (g%)	Total sugar (g%)	Reducing sugar (g%)	Density (g/cm^3)	Brix(°)	Ascorbic acid (mg%)
Organic	O1	0.10±0.00	6.42±0.50	3.17±0.08	1.02	8.15	2.41±0.60
	O2	0.07±0.01	6.32±0.41	4.80±0.17	1.03	9.56	2.93±0.79
	O3	0.09±1.69	4.52±0.35	2.45±0.08	1.02	6.83	3.00±0.53
	O4	0.13±0.01	4.75±0.25	4.08±0.19	1.02	6.83	3.23±0.39
	O5	0.16±0.00	6.40±0.28	2.33±0.07	1.04	8.81	2.67±0.23
	Mean ± SD	0.11±0.34^a	5.68±0.35^a	3.36±0.11^b	1.02±0.01^a	8.03±1.20^a	2.84±0.50^a
Certified Organic	O1	0.06±0.00	4.71±0.31	2.26±0.13	1.04	7.49	3.49±0.21
	O2	0.09±0.00	5.10±0.62	3.17±0.11	1.03	8.15	3.60±0.54
	O3	0.07±0.00	5.32±0.21	3.07±0.04	1.03	7.49	3.05±0.65
	O4	0.09±0.00	4.56±0.15	3.07±0.13	1.03	7.49	2.44±0.00
	O5	0.11±0.01	5.53±0.54	3.33±0.33	1.03	8.15	3.46±0.25
	Mean ± SD	0.08±0.00^b	5.04±0.36^a	2.36±0.14^b	1.03±0.00^a	7.75±0.36^a	3.20±0.33^a
Conventional	O1	0.08±0.01	3.45±0.12	4.35±1.00	1.04	8.81	3.58±0.77
	O2	0.08±0.00	5.34±0.49	4.63±0.22	1.04	8.81	4.39±1.18
	O3	0.08±0.00	5.27±0.73	3.83±0.70	1.03	8.15	3.25±0.22
	O4	0.08±0.01	3.17±0.06	3.17±0.06	1.04	8.15	2.09±0.42
	O5	0.08±0.00	3.62±0.26	3.62±0.26	1.04	9.46	3.01±0.68
	Mean ± SD	0.08±0.00^b	4.17±0.33^b	3.92±0.44^a	1.03±0.00^a	8.67±0.57^a	3.26±0.65^a

Data represent mean ± SD values of triplicate experiments. Tukey–Kramer Multiple Comparison test; Different letters indicate statistically significant differences at the 0.05 level.

significantly different ($p > 0.05$) in carrot samples, unlike the earlier study by Bender et al. (2009) in which the contents of β-carotene and ascorbic acid were higher in conventionally-grown than in organically-grown. Another study by Sikora et al. (2009) also showed that organic carrots contained significantly more ascorbic acid, carotenoids and phenolic acids in comparison to the conventional ones, which contradicted the findings of the present study.

Changes in the management of chemicals and agricultural practices are likely to affect the content of agricultural nutrients. So, the nutritional requirements and final nutritional contents of a particular crop may also vary depending on the cultivation (Hornick and Parr, 1987). Moreover, the nutritional composition is often more dependent on different weather conditions, and this influence interferes in the possible effect of cultivation system (Bender et al*.*, 2015).

Green Pepper (*Capsicum Annuum*)

For total titratable acidity, total sugar, density and soluble solutes the results obtained showed that there was no significant differences between conventional, organic and certified organic samples ($p > 0.05$) (Table 2).

In case of ascorbic acid, the certified organic samples presented higher average values (33.48 ± 2.99 mg%) than the conventional (19.25 ± 2.99 mg%) and organic samples (21.67 ± 2.14 mg%) at $p < 0.05$. Similar results have been reported by Hallmann and Rembialkowska (2012), which demonstrated that green peppers samples produced under an organic system presented higher average values of vitamin C.

Lettuce (*Lactuca sativa*)

The conventional lettuce samples had a higher tritratable acidity and ascorbic acid value than organic and certified organic samples ($p < 0.05$) (Table 3).

These results differ than those observed by Williams (2002) and Magkos et al. (2003), who reported that the vegetables produced under organic systems frequently had higher contents of vitamin C, when compared with those produced conventionally. Another study by Ismail and Fun (2003) also showed that the ascorbic acid content was found to be significantly lower in lettuce grown conventionally compared to the organically grown ones.

There were no significant differences ($p>0.05$) among the values of density, total sugar and soluble solids in lettuce samples. These results disagrees to those observed by Polat et al. (2008) who found that soluble

Table 2. Physico-chemical analysis of conventional and organically grown of green Pepper (*Capsicum Annuum*).

Parameter	Sample	Acidity (g%)	Total sugar (g%)	Reducing sugar (g%)	Density (g/cm^3)	Brix(°)	Ascorbic acid (mg%)
Organic	O1	0.15±0.00	2.43±0.09	2.14±0.10	1.02	4.14	28.55±1.90
	O2	0.13±0.00	1.96±0.02	2.27±0.05	1.01	4.82	14.63±2.57
	O3	0.09±0.00	2.80±0.08	2.61±0.08	1.01	5.49	17.02±1.70
	O4	0.15±0.00	2.59±0.07	2.74±0.16	1.01	5.49	19.16±1.91
	O5	0.13±0.00	2.45±0.06	2.31±0.06	1.01	5.49	29.02±2.63
	Mean ± SD	0.13±0.00[a]	2.44±0.06[a]	2.41±0.09[a]	1.01±0.00[a]	5.08±0.60[a]	21.67±2.14[a]
Certified Organic	O1	0.10±0.00	3.06±0.12	1.82±0.08	1.02	3.46	63.97±2.35
	O2	0.10±0.00	2.35±0.07	2.29±0.02	1.01	4.14	22.48±2.04
	O3	0.14±0.00	3.15±0.20	1.81±0.03	1.02	4.14	35.33±4.76
	O4	0.11±0.00	2.23±0.05	2.68±0.12	1.03	4.14	19.03±3.88
	O5	0.11±0.00	2.64±0.05	2.58±0.11	1.02	4.14	26.62±1.94
	Mean ± SD	0.11±0.00[a]	2.69±0.10[a]	2.23±0.07[a]	1.02±0.00[a]	4.14±0.48[a]	33.48±2.99[b]
Conventional	O1	0.17±0.00	2.62±0.07	2.45±0.13	1.01	4.14	19.75±2.66
	O2	0.13±0.00	2.94±0.11	2.17±0.13	1.02	4.82	20.27±2.26
	O3	0.12±0.01	2.720.08	2.29±0.04	1.01	4.82	22.81±2.98
	O4	0.12±0.00	2.25±0.05	2.13±0.05	1.02	4.14	20.29±0.0
	O5	0.1±0.00	2.12±0.04	2.34±0.14	1.02	4.82	13.63±1.07
	Mean ± SD	0.12±0.00[a]	2.53±0.07[a]	2.27±0.09[a]	1.01±0.0[a]	4.55±0.37[a]	19.35±2.99[a]

Data represent mean ± SD values of triplicate experiments. Tukey–Kramer Multiple Comparison test; Different letters indicate statistically significant differences at the 0.05 level

Table 3. Physico-chemical analysis of conventional and organically grown of lettuce (*Lactuca sativa*).

Parameter	Sample	Acidity (g%)	Total sugar (g%)	Reducing sugar (g%)	Density (g/cm^3)	Brix(°)	Ascorbic acid (mg%)
Organic	O1	0.03±0.00	0.79±0.01	1.46±0.02	1	2.09	0.29±0.03
	O2	0.04±0.00	0.75±0.00	1.39±0.02	1	0.7	0.27±0.04
	O3	0.04±0.00	0.78±0.01	1.42±0.01	1	2.09	0.44±0.02
	O4	0.03±0.00	0.8±0.01	1.44±0.01	1	1.4	0.39±0.00
	O5	0.04±0.00	0.79±0.01	1.49±0.01	1	1.4	0.29±0.06
	Mean ± SD	0.04±0.00[a]	0.78±0.01[a]	1.44±0.01[a]	1±0.00[a]	1.53±0.57[a]	0.33±0.03[a]
Certified Organic	O1	0.04±0.00	0.75±0.00	1.36±0.03	1.01	2.09	0.28±0.02
	O2	0.03±0.00	0.82±0.01	1.40±0.03	1.01	1.4	0.26±0.04
	O3	0.04±0.00	0.85±0.01	1.38±0.01	1	2.09	0.34±0.00
	O4	0.03±0.00	0.79±0.09	1.35±0.01	1.01	0.7	0.32±0.06
	O5	0.04±0.00	0.82±0.01	1.44±0.01	1.01	2.77	0.21±0.03
	Mean ± SD	0.04±0.00[a]	0.81±0.03[a]	1.39±0.02[a]	1±0.00[a]	1.81±0.78[a]	0.28±0.01[a]
Conventional	O1	0.04±0.00	0.75±0.01	1.45±0.01	1	1.4	0.24±0.06
	O2	0.04±0.00	0.79±0.01	1.29±0.01	1.15	0.7	0.34±0.02
	O3	0.06±0.00	0.66±0.00	1.49±0.01	1	1.4	0.71±0.14
	O4	0.03±0.00	0.80±0.01	1.36±0.06	1	2.77	0.86±0.11
	O5	0.73±0.00	0.70±0.11	1.51±0.01	1	1.4	0.76±0.05
	Mean ± SD	0.32±0.00[b]	0.74±0.06[b]	1.42±0.02[a]	1.03±0.0[a]	1.53±0.75[a]	0.58±0.07[b]

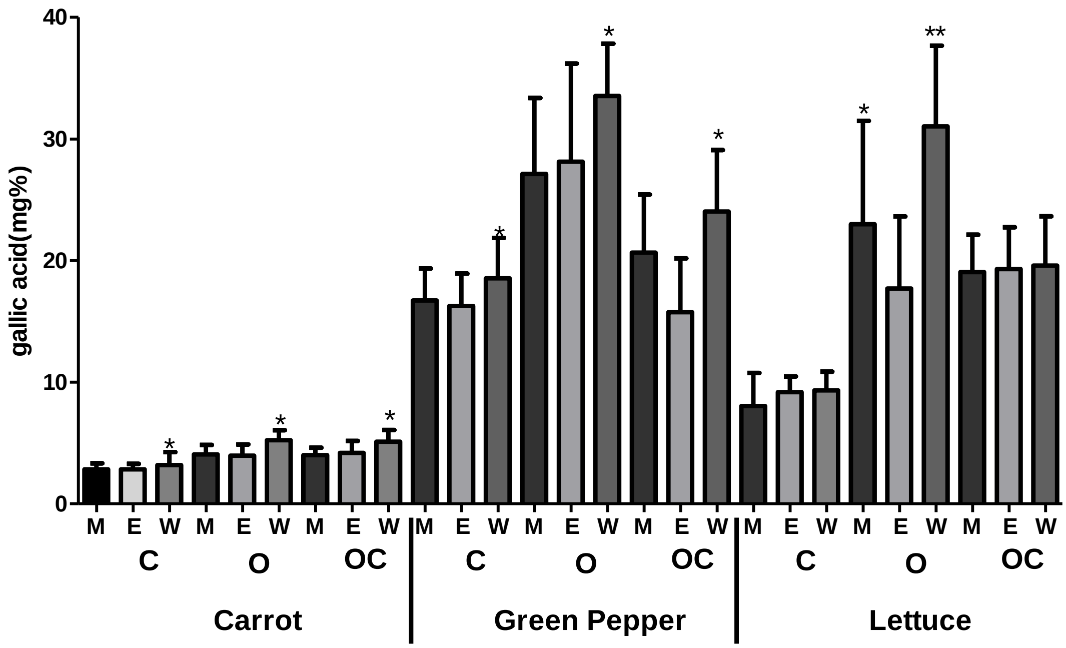

Figure 1. Total Phenolic Compounds in samples of carrots, peppers and lettuce organic (O) , conventional (C) and certified organic (OC) extracted by methanol, ethanol and water. *statistically different (p <0.05).

sugar contents of lettuce growing on applicantions were significant.

Organic acid, soluble sugars and pigments are important components that may contribute to flavor and nutritional value of vegetables, indicating the quality of these products. However the production system, maturation stage, the environmental temperature (Guevara-Figueroa et al., 2015), incident radiation (Caldwell and Britz, 2006) and soil type (Pinto et al., 2014) may change their chemical characteristcs.

Antioxidant activity and phenolic compounds

Plants produce their own means of defense against external agents such as pathogens, predators and even ultraviolet radiation. Phenolic compounds are examples of these means of defense which provide protection against such stresses (Dai and Mumper, 2010; Mittler, 2002). Moreover they take part in processes responsible for color, aroma and astringency in various vegetables. Polyphenolics, thiols, carotenoids, tocopherols and glucosinolates are frequently found in fruits, vegetables and grains. The determination of total phenolic compounds revealed that the use of water as extractor was more efficient compared to others extractors used (Figure 1). Considering this extractor, certified organic and organic samples showed higher total phenolic compounds ($p<0.05$) than those conventional in all samples analyzed vegetables (Table 4). The production of secondary metabolites in plants are influenced by environmental factors because they have an important role in the adaptation of plants and studies have hypothesized that the organic system had higher levels of phenolics (Young et al., 2005).

Young et al. (2005) reported no significant differences in phenolic compounds in organic crops of lettuce and cabbage samples, however, the total phenolic content in conventional pak choi (*Brassica rapa subsp. Chinensis*) samples, measured by Folin- Ciocalteu assay, was significantly lower than the organic samples. This seems to be associated with an increased attack plants in organic plots by insects. On his study using samples of organic green peppers, Amor et al. (2008) observed higher values of phenolic compounds, when compared to the conventional samples. That goes with this present study and confirm the results.

Antioxidants are neutralizing free radical mechanism and act by preventing the damage that these free radicals can cause, for example, damage human cells and DPPH assay has been a proven method to determine the antioxidant capacity (Hossain et al., 2013). Conventional samples of carrot and green pepper showed less antioxidant activity ($p < 0.05$) when compared with the organic samples (Figure 2). A study by Kazimierczak et al. (2008) showed that the antioxidant capacity was lower in conventional currant when compared to organic. Leclerc et al. (1991) showed that organic carrots had more β –carotene and organic celery had more vitamin C than crops grown conventionally. Results of antioxidant

Table 4. Mean and standard deviation of total phenolic compounds (mg% GAE) in carrot samples, pepper and lettuce oganic (O), conventional (C) and certified organic (OC) extracted by water.

Samples	C	O	OC
Carrot	2.69±1.07[a]	5.40±0.81[b]	4.64±0.96[b]
Green Pepper	19.37±4.96 [a]	32.79±9.60 [b]	29.02±5.87 [b]
Lettuce	10.77±7.15 [a]	33.64±6.64 [b]	19.31±3.19 [b]

mg% GAE= gallic acid equivalent mg / 100 g.

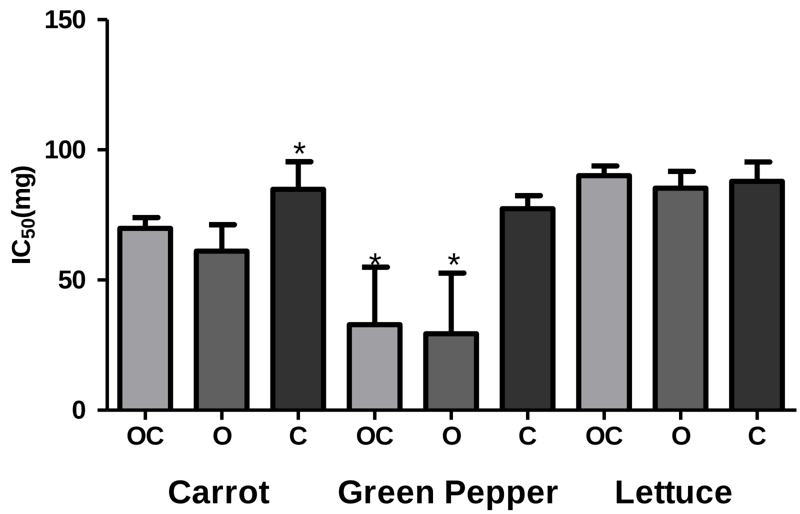

Figure 2. Antioxidant Activity by DPPH assay**.** IC_{50} value in samples of carrot , peppers and lettuce organic (O) Certified Organic (OC) and conventional (C) of different batches (*p <0.05 Tukey test).

activity in this study confirm earlier work (Hallmann and Rembialkowska, 2012; Worthington, 2004) that higher average values were obtained for samples of organic and certified organic green peppers as compared to the conventional ($p < 0.05$). There were no significant differences between the different forms of production in lettuce samples ($p>0.05$).

The effectiveness of the antioxidant capacity depends on the chemical structure and concentration of polyphenols in vegetables. This capacity in plant extracts can be determined by various analytical methods such as capture of the peroxyl radical (ORAC,TRAP), power metal reduction (FRAP,CUPRAC), the hydroxyl radical capture (deoxyribose method), capture of the organic radical (ABTS, DPPH) and the first thing to do is to isolate phenolic compounds from vegetables.

A study by Ribeiro et al. (2010) showed that the investigated extracts (methanol, methanol 50%, methanol acidified, methanol 50%: acetone 70% and acetone 70%) differed significantly ($p<0.05$) in their total phenolic content that is contributed to the different antioxidant activities (% DPPH reduction). Faller and Fialho (2010) analyzed the phenolic compounds and the antioxidant capacity of organically and conventionally grown vegetables, which used a extraction solution of 1.2 M HCl and 50% methanol. The conclusion was the ability of HCl to extract fraction of phenolic compounds bound and quantifies the free and bound phenolics, generating probably increased in phenolic content and antioxidant activity.

According to Wu and Prior (2005) there is not a most appropriate or better extractor for analysis of phenolic compounds but an issue that should be considered is that most phenolic compounds are water soluble. Due to the low viscosity of solvents, their density becomes smaller and therefore the ease of diffusion of the bioactive compounds becomes greater (Naczk and Shahidi, 2006).

Through the correlation between the total content of phenolic compounds and vitamin C with antioxidant activity in carrot samples, organic pepper and lettuce, certified organic and conventional, it was found that the only identified correlation was between phenolic compounds and antioxidant activity in green pepper samples ($p = 0.0433$) (Table 5).

Antioxidant activity depends mainly on phenolics, which are considered more potent antioxidants as compared to

Table 5. Correlation coefficient between the total content of phenolic compounds and vitamin C with antioxidant activity carrot , peppers and lettuce organic , certified organic and conventional.

Vegetable	Parameter	Correlation coefficient	p-value	N
Carrot	Phenolics x Antioxidant activity	0.7049	0.4356	5
	Vitamin C x Antioxidant activity	0.3371	0.7811	5
Green Pepper	Phenolics x Antioxidant activity	0.9977	0.0433*	5
	Vitamin C x Antioxidant activity	0.8289	0.378	5
Lettuce	Phenolics x Antioxidant activity	0.6465	0.5525	5
	Vitamin C x Antioxidant activity	0.2759	0.822	5

vitamins (Koleva et al., 2002; Usenik et al., 2008). The non-existence of correlation in carrots can be explained because the bioactive compounds with recognized antioxidant activity present in the carrot are mainly, according to Singh et al. (2012), β-carotene, α-carotene, lycopene and lutein. The peppers are rich in capsaicinoids which are responsible for the pungent taste and which have a direct relationship with the antioxidant activity of these foods (Materska and Perucka, 2005). From the analysis of the antioxidant activity was observed that the different types of lettuce cultivation was not significant difference so it influenced the results of this correlation.

Conclusion

Differences were observed in chemical characteristics between of organic and conventional cultivation of vegetables, mainly due to the great variety among the lots. On the other hand, the organic samples had higher antioxidant capacity and amounts of phenolic compounds superior when compared to conventional samples. Thus, the data reinforce the need for greater standardization in production of vegetables without loss of nutritional quality and maintenance of bioactive characteristics. Environmental factors such as weather and soil conditions of different regions can cause variations in the physical and chemical characteristics of the plants. So more studies are required at different locations to prove the superiority of the organic system over conventional one.

Conflict of Interests

The authors have not declared any conflict of interest.

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