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The concentration of minerals and physicochemical contaminants in conventional and organic vegetables

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ABSTRACT

In this study, we performed a comparative analysis of the physical-chemical composition and pesticide residue content of lettuce, peppers, and tomatoes that were grown in organic and conventional systems. The vegetables were purchased at the Food Supply Centre of Pernambuco [Centro de Abastecimento Alimentar de Pernambuco – CEASA/PE], Pernambuco state, Brazil. The physical-chemical composition of the vegetables was determined according to the analytical procedures of the Association of Official Analytical Chemist. The minerals (Cu, Cr, Fe, K, Mn, Mg, Na, and Zn) and the heavy metals (Cd, Ni, and Pb) were assessed using atomic absorption spectrometry, and the pesticide residues were determined using a multi-residue analysis. The results were compared by means of a Student's *t*-test. Principal component analysis was performed to investigate the correlations between the minerals and the heavy metals. The measurements of weight, length, and width of all three of the vegetables that were assessed were higher in the conventional group. There were significant differences ($p < 0.05$) in the proximate composition of conventional and organic lettuces (moisture, ash and protein) and in all the parameters of conventional and organic peppers. To tomatoes there wasn't significant difference ($p > 0.05$). All three of the organic vegetables were higher in total dietary fibre. The composition of the minerals and heavy metals varied between all three vegetables. Contamination by pesticide residues was found in conventional peppers and organic tomatoes.

1. Introduction

During the last decades, the alternative culture systems have been developed because of the growing societal concern with sustainability, safety and quality of conventional products.

The term "organic food" refers to food that is free from artificial compounds such as chemical fertilisers and pesticides, veterinary drugs, hormones and antibiotics, and genetically modified organisms. The adoption of organic practices has attracted the attention of the food production sector involves perceptible environmental consequences in the quality of the food, the promotion of human health, an environmental balance, the preservation of the biodiversity and biological activities of the soil (Gomiero, Pimentel, & Paoletti, 2011; Turner, Davies, Moore, Grundy, & Mead, 2007).

On the other hand, conventional farming foods are produced using inorganic pesticides which increase the content of heavy metals in the soil and the plants in the long run, besides causing intoxication and leading to the appearance of serious diseases such as cancers in the farmers that handle the agrochemicals, as well as to the consumers of these foods (Paulose, Datta, Rattan, & Chhonkar, 2007; Santos, Santos, Conti, Santos, & Oliveira, 2009). Metals are intrinsic components in the Earth's crust, however the soil contamination with heavy metals is an environmental problem in a worldwide scale nowadays and it is becoming more and more important as industrialization grows (Salvatore, Carratu, & Carafa, 2009; Tiwari, Singh, Patel, Tiwari, & Rai, 2011).

In the last few years, there has been a lot of discussion about sustainability and environmental development, and proportionally

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there has been an increase on the demand for organic foods. These ones are widely perceived as being tastier and healthier than the products produced the conventional way, moreover the production process is less harmful to the environment, what is explained by the position organics are taking in the global food market and the consumption pattern (Zanoli, Gambelli, & Vairo, 2012). Worldwide production of organic food might still grow substantially, being often considered as one of the largest growing markets in the food industry (Hjelmar, 2011).

There are growing number of studies comparing organic and conventional farming foods concerning the physicochemical and microbiological composition, phenolic compounds, minerals in plants and soil, especially in some foods/products: wine (Cozzolino, Holdstock, Dambergs, Cynkar, & Smith, 2009); coffee, before and after the conversion to the organic farming (Santos et al., 2009), corn (Ariño, Estopañan, Juan, & Herrera, 2007); eggplants (Luthria et al., 2010; Raigón, Rodriguez-Burruezo, & Prohens, 2010); tomato and lettuce (Kelly & Bateman, 2010; Wiebner, Thiel, Krämer, & Köpke, 2009), among others. However, there is still a lot of controversy about the higher nutritional value of organic foods when they are compared to the conventional foods, especially the micronutrients.

Much of the population has proved willing to pay higher prices for organic products, particularly because of those previously referred health benefits and their connection to the environmental preservation (Schifferstein & Oud Ophuist, 1998; Zander & Hamm, 2010). Thus, the market for organic products shows itself as promising in the food sector, with high growth rates in the last decades. However, despite organic foods are already being consumed by more affluent Brazilians, in general the Brazilian population is concerned about the food they eat, but it also lacks information on the characteristics of such products (Brasil, 2007).

The organic sector has experienced significant growth over the past two decades. In Brazil are small farmers who are facing the sector and have faced challenges to come in and take advantage of this growth in a sustainable manner (Blanc & Kledal, 2012).

Little is known about the safety of organic food compared with those obtained by conventional methods. The production of green vegetables varies throughout the year in Brazil and they have a good production and consumption mainly in the Northeast, where this research was conducted. Thus, aiming the daily consumption by Brazilian and organic vegetables are available in the local market economies such as lettuce, pepper and tomato, which also have an increasing production in organic farming, it was noticed there is a need for a study of their physicochemical characteristics, as well as chemical contaminants in these foods. These vegetables are part of the diet worldwide (Agarwa & Rao, 2000). Therefore, this study sought to comparatively analyse the composition of minerals, heavy metals and pesticide residue of vegetables previously quoted that were grown using organic and conventional systems.

2. Materials and methods

2.1. Samples

Samples of the same kinds of curly lettuce (*Lactuca sativa* L.), tomato common (*Lycopersicum esculentum*) and green pepper (*Capsicum annuum* L.) from conventional and organic farming were acquired on 6 different stores, 10 samples (of the 2 kg) in each store at the Food Supply Centre of Pernambuco (Centro de Abastecimento Alimentar de Pernambuco – CEASA/PE) and from the Organic Market, respectively from January to April 2011.

The samples were collected based on the cultivation system and the type of vegetable. The physicochemical analyses were realized in the Experimentation Laboratory of Food Analysis (Laboratório de Experimentação de Análises em Alimentos – LEAAL) of the Department of Nutrition and the Laboratory of Environmental Engineering and Quality (Laboratório de Engenharia Ambiental e Qualidade – LEAQ) of the Department of Chemical Engineering at the Federal University of Pernambuco (Universidade Federal de Pernambuco – UFPE). The analyses of pesticide residue were realized in the Institute of Technology of Pernambuco (Instituto de Tecnologia de Pernambuco – ITEP).

The vegetables were chopped in a food processor, homogenised, placed in polystyrene packaging, identified, and analysed. The samples for analysis were kept refrigerated at 7 ± 2 °C. For the multi-residue analysis, 2 kg of each vegetable was sent intact to ITEP and then conducted experiments.

2.2. Physicochemical analysis

2.2.1. Physical analysis

The assessed physical characteristics were the weight (using a semi-analytical electronic scale, Bioprecisa JA 3003N, 300 g/0.001 g), the longitudinal length, and the cross-sectional width (using a calliper, Digimess, 200 mm/8″).

2.2.2. Proximate composition analysis

The following analyses were performed: moisture content (AOAC, 2000 – 969.38b); ash content (AOAC, 2000 – 942.05); pH (AOAC, 2000 – 981.12); the titratable acidity (AOAC, 2000 – 947.05); protein content (AOAC, 2000 – 920.87); ether extract (AOAC, 2000 – 920.39C); and total dietary fibre (AOAC, 2000 – 993.21).

2.2.3. Analysis of minerals and heavy metals

The minerals copper (Cu), chromium (Cr), iron (Fe), potassium (K), magnesium (Mg), manganese (Mn), sodium (Na), and zinc (Zn) and the heavy metals cadmium (Cd), nickel (Ni), and lead (Pb) were investigated in the organic and conventional vegetables because these minerals and metals have been described in the literature to be significantly present in these foods.

The minerals and the heavy metals were determined using an atomic absorption spectrometer (Varian Spectra AA240FS) that was equipped with a deuterium background correction lamp and an air-acetylene flame (AOAC, 2000 – 975.03B) using the dilution factor 1:10. 10 mL aliquots for each mineral or heavy metal from the different vegetables and crops were used to read. Calibration curves were constructed using solutions of increasing concentrations of the investigated minerals and metals to determine the linear range. The selected spectral lines are main with the wavelength for Cr, Cu, K, Na, Fe, Mg and Mn 425.43, 324.8, 769.9, 589.0, 248.3, 285.2 and 202.6 nm, respectively. And heavy metals Cd, Ni, Pb, 780, 352.45 and 405.781 nm respectively. The results were analysed by calculating the linear regression using the least squares method. The correlation coefficient was 0,9993, showing that 99.93% of the variation around the mean is explained by the model. The assessments were performed in duplicate.

2.2.4. Multi-residue analysis

For the toxicological analysis, a multiresidue screen was performed to identify the pesticide residues. The samples were prepared (cut and homogenised) and were subjected to the following procedures: a portion of each vegetable sample was frozen individually. The extraction and purification were performed, and the multi-residue content was quantified. A process controller was added to each sample, and the extraction and purification were performed using the QuEChERS (Quick, Easy, Cheap, Effective,