

Full Length Research Paper

Determination and comparison of vitamin C, calcium and potassium in four selected conventionally and organically grown fruits and vegetables

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It is evident that the growing interest in organically grown produce has correspondingly necessitated the debate on the nutritional supremacy between organically and conventionally grown produce. A study was carried out to determine and compare vitamin C, calcium and potassium in organically and conventionally grown cabbage, carrots, Cos lettuce and Valencia oranges. Samples were purchased from local supermarkets within Central Coast, New South Wales in Australia from late March to early April 2007. Vitamin C content was determined by 2,6-dichloroindophenol titrimetric method while calcium and potassium were determined by atomic absorption spectroscopy. Results from the study showed inconsistent pattern with respect to vitamin C, calcium and potassium contents in the conventionally and organically grown samples. No significant differences were observed in vitamin C content in conventionally and organically grown cabbage, carrots and Cos lettuce while significant differences were observed in Valencia oranges which showed higher vitamin C content in organic Valencia oranges as compared to conventional ones (51.8 to 43.4 mg/100 g fresh weight). Results on calcium and potassium contents showed significant differences in all the samples with the trend of higher values for organically grown cabbage, carrots and Cos lettuce as opposed to their conventionally grown counterparts. However, for Valencia oranges, results showed that the calcium and potassium contents were significantly higher in conventional Valencia oranges compared to the organic Valencia orange (54.5 and 192.0 mg to 51.8 and 189.5 mg/100 g, respectively).

Key words: Organic, conventional, atomic absorption spectroscopy, 2,6-dichloroindophenol.

INTRODUCTION

The debate about the nutritional superiority of organically and conventionally grown products has been gathering momentum for some time especially in developed countries. The debate has cut across different agricultural produce animal products inclusive. Organic products are those products, which are produced under controlled cultivation conditions with the provisions of the regulation on organic farming. Requirements for organic certification vary from country to country and generally involve a set of production standards for growing, storage, processing,

packaging and shipping. Organic certification is intended to assure quality and prevent fraud. There have been many reasons why the demand for organic produce has been growing as reported by other findings. Magkos and Zampelas (2003) reported that one of the primary reasons for purchasing organically grown produce is the perception that they are more nutritious than the conventional produce. They further reported there are only few well-controlled studies that are capable of making valid comparison and therefore, compilation of results is difficult and generalization of the conclusions should be made with caution.

It is evident that with people's growing awareness of health and the environment, public interest is increasingly

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focusing on the problem of the quality of foods and that considerable attention is being paid in organically grown produce considering the fact that the conventionally grown products have always been already there. Meier-Ploeger (1990) as reported by Woese et al. (1996) stated that roughly 1% of the total consumption of foods in Germany was accounted by organic produce and further reported as quoted from Bailieux and Scharpe (1994) that the European Union was forecasting an increase to approximately 2.5% by year 2000. In the United Kingdom, there is a growing demand in organic foods though the market can only provide 30% of the organic food consumed which means the rest needs to be brought from more developed market abroad. Increased numbers of farmers are turning to organic production but their farms must undergo a conversion period before they can obtain the coveted organic certification (<http://www.thesite.org/healthwellbeing/fitness>).

Although the interest in the organically grown foods has been on increase, there have not been substantial studies to substantiate convincingly that organically grown foods are nutritionally superior to their conventionally grown counterparts. The debate is even further intensified by the facts that for some of the studies that have been carried out to compare the nutritive value between organically and conventionally grown produce, there have been some conflicting findings regarding the nutritive contents in the organic and conventional produce. It is this dilemma of insufficient information on the nutritive value of conventionally and organically grown foods that calls for renewed efforts in further nutrient determination so that future generalization of conclusions about the nutritive value of these two groups can be made from substantial amount of sources.

MATERIALS AND METHODS

Sample collection and preparation

Samples for the study were purchased in local Woolworth's supermarkets within Central Coast, in New South Wales, Australia from late March to early April 2007. The samples were purchased straight from the refrigerated shelves and with the exception of conventional Cos lettuce; all were packaged. Additionally, the organically certified produce had best before dates while the conventional produce had no best before dates. All the samples were thoroughly cleaned using deionised to remove adhering contaminants. For the analysis of vitamin C in the samples, determination was done on the same day of purchase to counteract the instability of vitamin C. Samples to be used in the determination of calcium and potassium were finely chopped and vacuum oven dried at 70°C until constant weights were achieved. The dried samples were ground to fine powder and stored in airtight bottles in readiness for mineral analysis with respect to calcium and potassium. With exception of Valencia oranges, the samples were peeled, seeds and pith removed and then crushed in a food blender. The crushed samples were vacuum oven dried at 70°C and care was observed not to increase the temperature to avoid Maillard reactions in the dried samples. All the analysis was conducted at the University of Newcastle, Ourimbah campus.

Vitamin C determination

Vitamin C was determined by using the procedure as outlined by Nielsen (1998) Food Analysis Laboratory Manual Chapter 7 Vitamin C Determination by Indophenol Method and AOAC International Methods of Analysis vol 16 Method 967.21. 10 g of each of the samples with the exception of Valencia oranges was accurately weighed and ground using mortar and pestle with an additional of 20 ml of metaphosphoric acid acetic acid. The mixture was further ground and strained through muslin and the extract was made up to 100 ml with the metaphosphoric-acetic acid mixture. 5 ml of the metaphosphoric acid-acetic acid solution was pipetted into three of the 50 ml Erlenmeyer flask followed by 2 ml of the samples extract. The samples were titrated separately with the indophenol dye solution until a light rose pink persisted for 5 s. The amount of dye used in the titration were determined and used in the calculation of vitamin C content. Determination of vitamin C in Valencia oranges was done by extracting the juice using juice extractor and 2 ml of the muslin-filtered juice was used in titration for the determination of vitamin C.

Calcium and potassium determination

Calcium and Potassium were determined as outlined in AOAC International Methods of Analysis (1995) Chapter 3, page 4. Calcium was determined by ashing accurately weighed 1 g of dried and ground sample into glazed, high-form porcelain crucible for 2 h in a muffle furnace at 500°C. The ashed sample was let to cool and 10 drops of deionised water followed by 3 – 4 ml of nitric acid were added to the sample. Excess nitric acid was evaporated by placing the sample on a hot plate set at 100 - 120°C. The sample was returned to furnace and ashed for additional 1 h and after being cooled, the ash was dissolved in 10 ml hydrochloric acid and transferred quantitatively to 50 ml volumetric acid. In order to counteract chemical interferences, which have been fairly documented to depress calcium absorbance, a releasing agent in form of lanthanum (10000 µg/ml) was added in all replicates and standards to obviate combined interference effects. For potassium determination, the same procedure as outlined for calcium was followed. Potassium is partially ionized in the air-acetylene flame and to suppress ionization, cesium nitrate (1000 µg/ml cesium) was added in all the solutions including the blank. In case of higher concentrations of potassium in all the samples, original samples were diluted in the range of 300 – 500 times in order to achieve the optimum working conditions for the instrument. Analysis for both calcium and potassium was carried out using atomic absorption spectroscopy set at different wavelengths for the optimum working conditions of the two minerals. The burner height was manually adjusted on the instrument to ensure maximum absorption.

Statistical analysis

All the data obtained from the determinations of vitamin C, calcium and potassium from the organically and conventionally grown cabbage, cos lettuce, carrots and Valencia oranges were subjected to JMP 5.1 statistical package. Six readings for vitamin C, Calcium and Potassium as well as 3 readings for dry matter contents of the experimental samples were used in the analysis. Comparisons of means and level of significance were tested as well as one way analysis of variance (ANOVA) for each category of sample was compiled.

RESULTS AND DISCUSSION

Results on vitamin C (Table 1) revealed with the excep-

Table 1. Vitamin C content in mg per 100 g fresh weight of sample (n = 6) of conventionally and organically grown fruits and vegetables.

| Sample | Conventional | Organic |
|-----------------|--------------|------------|
| Cabbage | 32.1 ± 0.8 | 31.3 ± 0.8 |
| Carrots | 4.9 ± 0.3 | 4.8 ± 0.2 |
| Cos lettuce | 10.3 ± 0.4 | 10.3 ± 0.4 |
| Valencia orange | 43.4 ± 0.7 | 51.8 ± 1.7 |

tion of organically and conventionally grown Valencia oranges that there were no significant differences in vitamin C content between organically and conventionally grown samples. However, significant differences were observed in vitamin C content for the conventionally and organically grown Valencia oranges. These results on vitamin C content for cos lettuce, cabbage and carrots are not in agreement with what Worthington (1998) reported but tends to back up the results on the organically and conventionally grown Valencia oranges. In her review, she reported that organically grown crops contained significantly more vitamin C than the conventionally grown crops. The higher vitamin C value in organically grown Valencia oranges backed up the findings of Gyorene et al. (2006) who reported that organically produced plant derived products have a higher nutritional value than conventional ones as well as those of Caris-Veyrat et al. (2004) who found out that concentrations of vitamin C and polyphenols remained higher in purees made out of organic tomatoes. Another observation has also been shown on the levels of the vitamin C content in comparison to other previous findings on the experimental samples. Singh et al. (2006) in their study on the antioxidant phytochemicals in cabbage found out that the range of vitamin C content in eighteen cabbage cultivars was 5.66 - 23.5 and this findings support the argument by Harker (2004) who reported that comparisons between organically and conventionally grown produce are confounded by other factors such as cultivar type, harvest maturities as well as soil type. Other researchers have found out there have been reductions in mineral content of fruits and vegetables with time. Mayer (1997) in her article on historical changes in the mineral content of fruits and vegetables found out that there were significant reductions in the levels of calcium, magnesium and sodium in vegetables and magnesium, iron and potassium in fruits over a 50-year period in Britain. She argued that questions should be asked on whether the apparent decline minerals is caused by diminishing levels in soils, poor availability, choice of cultivars or other changes in the food systems. The results on the absence of any significant differences in vitamin C content for the organically and conventionally grown samples is supported by the findings of a three year research conducted in Canada by Warman and

Table 2. Calcium content (mg/100 g) (n = 6) of conventionally and organically grown fruits and vegetables.

| Sample | Conventional | Organic |
|-----------------|--------------|------------|
| Cabbage | 39.0 ± 1.4 | 44.0 ± 1.4 |
| Carrots | 31.7 ± 1.0 | 36.3 ± 1.2 |
| Cos lettuce | 30.7 ± 1.2 | 35.7 ± 1.2 |
| Valencia orange | 54.5 ± 1.6 | 51.8 ± 1.7 |

Table 3. Potassium content (mg/100 g) (n = 6) of conventionally and organically grown fruits and vegetables.

| Sample | Conventional | Organic |
|-----------------|--------------|-------------|
| Cabbage | 253.2 ± 2.3 | 287.7 ± 3.1 |
| Carrots | 320.7 ± 4.2 | 326.8 ± 2.3 |
| Cos lettuce | 278.3 ± 2.7 | 326.2 ± 3.3 |
| Valencia orange | 192.0 ± 1.4 | 189.5 ± 1.9 |

Havard (1996) on the yield, vitamin and mineral contents of organically and conventionally carrots and cabbage. They found out that the yield and vitamin content of carrots and cabbage were not affected by treatments but were quick to caution that more research is required to compare compost with conventional fertilizers in both short and long term crop rotation systems. In a study carried out by Bordeleau et al. (2002) on the comparison of organic and conventional fruits and vegetables, it was reported as quoted from Williams et al. (2002) that in order to produce significant results, comparisons should only be made using identical strains of plants managed under similar conditions to keep genetic and environmental variations at a minimum. William further stated that many studies involve a small number of samples, which leads to low reliability of results and does not allow generalizations and provide no details about variety, age and degree of ripeness of plant samples even though these factors seriously influence the concentration of different ingredients in samples. The same study as quoted from Kumpulainen (2001) reported that plants should be cultivated in similar soils under similar conditions, be pre-treated similarly, sampled at the same time and analysed by accredited laboratories employing validated methods. It was found out that organically grown tomatoes generally had higher levels of quercetin, kaempferol, total phenolics and ascorbic acid as compared to conventional tomatoes. Results on calcium and potassium (Tables 2 and 3) on the other hand, showed significant differences between organically and conventionally grown samples. All comparisons showed higher values of calcium and potassium in organically grown cabbage, carrots and Cos lettuce as opposed to their conventionally grown counterparts with the exception of Valencia oranges which showed higher values for both calcium and potassium in conventional Valencia oranges

Table 4. Dry matter content of the samples (%) (n = 3) of conventionally and organically grown fruits and vegetables.

| Sample | Conventional | Organic |
|-----------------|--------------|------------|
| Cabbage | 10.1 ± 0.3 | 10.0 ± 0.2 |
| Carrots | 10.7 ± 0.5 | 11.0 ± 0.6 |
| Cos lettuce | 5.1 ± 0.2 | 5.2 ± 0.2 |
| Valencia orange | 13.4 ± 0.2 | 13.6 ± 0.2 |

than in organic oranges. The findings on this study supported the report by Worthington (1998) who reported in his review of literature that organically grown crops contained significantly more vitamin C, magnesium, iron and phosphorous compared to the conventionally grown crops. The same observations were echoed by Gennaro and Quaglia on their article on "Food safety and nutritional quality of organic vegetables" as quoted from http://www.actahort.org/members/showpdf?booknrarn=614_100 (retrieved on 20th May 2007) indicating that mineral content has not shown the same regular trend, but appears to be higher amounts of some nutritionally significant minerals in organic compared to conventional crops. It is evident that the issue on the comparison of nutrient content of organic and conventional crops is a hotly debated one and it will continue to raise many questions about other findings. Matthew (2002) in his response to Worthington on nutritional quality of organic versus conventional fruits, vegetables and grains argued that the data used to make the comparisons were not suited for the purpose and that statistical tests are based on various assumptions. He further argued that it was simply impossible to tell whether those assumptions such as growing conditions were met for the data used. The results which showed a higher mineral content with regards to calcium in conventionally grown Valencia oranges supported the findings of the reviews by Woese et al. (1997) who found out 6 reviews reported higher calcium content in conventionally grown crops as compared to organically grown crops. Results on dry matter of the all the organically and conventionally grown samples (Table 4) revealed that there were no significant differences in dry matter content between the two categories. This revelation is not in agreement to other studies which have found out that organically grown crops have a higher dry matter content compared to conventionally grown crops. A study focusing on commercial production of processing tomatoes with matched organic and conventional fields conducted by Barret, Weakley, Diaz and Watnik (2007) found out individual analysis of variance results indicated that tomato juice prepared from organically produced tomatoes on some farms was significantly higher in soluble solids, higher in consistency and titratable acidity.

Conclusions

The findings of this study have revealed that the trend in the level of significance with respect to vitamin C, calcium and potassium in organically and conventionally grown cabbage, carrots, Cos lettuce and Valencia oranges did not follow a regular and consistent pattern. It was observed in this study that there were no significant differences in vitamin C content between organically and conventionally grown cabbage, Cos lettuce and carrots while significant differences were observed in organically and conventionally grown Valencia oranges with the organic Valencia oranges showing a higher values.

From the results as well as other previous findings, it is very evident that there is still controversy on nutritional superiority of organic and conventional produce because there are numerous confounding factors that make it difficult to establish a standardized environment in which to produce the two food sources. It is therefore highly recommended that future studies on organically and conventionally grown produce should attempt to address confounding factors such as climate, soil type, crop type, fertilizer application, post harvest handling and others before valid conclusions can be made.

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