Nutritional Quality Of Silver Beet And Tomatoes Grown In Secondary Treated Wastewater

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Abstract

With decrease rainfall in parts of the world, increase in population and an increase in demand for fresh foods, water conservation is becoming one of the biggest challenges today. A possible solution to this is wastewater reuse. However, one of the biggest challenges with wastewater reuse in food production is the uncertainty of the nutritional quality of produce. Combining the hydroponics method of growing edible food crops while using secondary treated domestic wastewater requires less space than traditional agricultural methods. This also aids in water conservation by reusing the treated effluent. The nutritional quality of tomatoes and silver beet growing in secondary treated domestic wastewater were compared to those grown in a commercially available hydroponics solution, as well as, produce purchased from a local supermarket. The tomatoes and silver beet were analysed for total carotenoids, total soluble solids and ascorbic acid concentrations. The nutritional quality of the wastewater grown tomatoes and silver beet was comparable to those grown in the hydroponic solution and those purchased.

Key words: wastewater reuse; nutrition; silver beet; tomatoes

Introduction

There have been numerous studies that have been conducted on the potential of treated domestic wastewater to provide essential nutrients for plant growth, however there are less studies on the nutritional quality of the edible food crops grown in secondary treated domestic wastewater and using a hydroponics setup. Nutritional quality of food crops is also an important factor to consider, especially when using treated effluent as the main nutrient source for food crops. Carotenoids, ascorbic acid (vitamin C) and total soluble solids (TSS) are some of the important nutritional parameters used to assess fruit and vegetable quality (Bourne and Prescott, 2002).

Carotenoids levels are an important quality aspect in fruit and vegetables for human consumption (Thane and Reddy, 1997). One of the most important forms of carotenoids in tomatoes is lycopene, which was reported to aid in preventing cancer (Abushita et al., 2000; Fröhlich et al., 2006). The measure of TSS is done in % Brix, which is a refractive index used to indicate the total soluble solids present (Baxter et al., 2005). The higher the TSS in fruits, the better the taste of fruits (Fridman et al., 2000). Spinach and tomatoes are one of the best sources of ascorbic acid (vitamin C) (Michaelsen et al., 2003). Vitamin C is important for prevention of scurvy and also encourages healing of wounds (Michaelsen et al., 2003). Therefore the levels of carotenoids, TSS and ascorbic acid are important elements determining the nutritional quality of the vegetables and fruits.

The aim of this study was to compare the nutritional quality of tomatoes and silver beet grown in different hydroponics media (WW and CM), with those bought in local supermarkets but were organically grown (O).

Materials and methods

Wastewater and control medium

The secondary treated domestic wastewater (WW) was collected from a domestic wastewater treatment plant (Perth, Western Australia) in 200L drums for the experiments. The wastewater was collected and used within 24 hours. The control medium used was a commercially available hydroponics nutrient solution (Ag-grow by Aquaponics WA) for fruits and vegetables. This nutrient solution was chosen for this study as it was readily available and provided a representation of optimum growth conditions. The control medium (CM) was prepared as per the specified ratio of 5mL of hydroponics medium to 1L of water, recommended for vegetables, fruits and flowers. The nutrient solution retention time was 14 days.

Plant selection

Common edible food crops chosen for this study were silver beet (*Beta vulgaris*), tomato (*Lycopersicum esculentum*). Seedlings were obtained from a local nursery.

Hydroponics design

The experiment was conducted in a greenhouse (Figure 1) to provide uniform conditions throughout the growth phase. Secondary treated wastewater was pumped from a 42L reservoir to the channel where plants were grown. The 295 x 12 x 12cm channels were connected by an inlet and outlet to the reservoir. The volume of solution in channels at any one time was approximately 7L. The effluent was drained by gravity flow back into the reservoir. Each channel was set up as shown in Figure 2. Uniform-sized seedlings were purchased from a commercial nursery and planted in a pot containing expanded clay balls, which were commercially available and inserted into the eight planting slots of each channel. The planting slots of the channels were 8cm x 9cm.

Figure 1: Greenhouse and hydroponics set-up

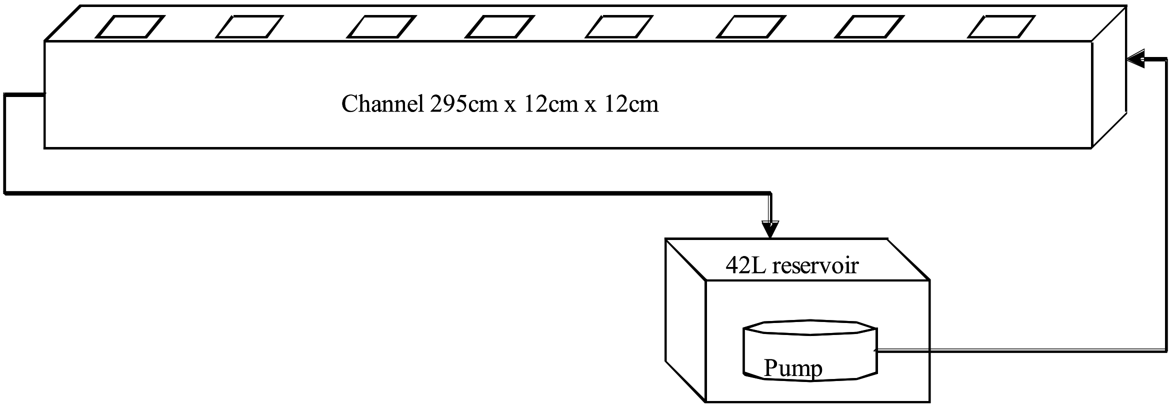

Figure 2: Hydroponics design

The experiment was conducted in triplicate (for both wastewater and control medium (commercial hydroponics medium)) with 8 seedlings of a species in each channel. Pumping from the reservoir into the channels and recirculation of effluent were considered to provide adequate aeration. The medium was changed every 4-5 weeks 14 days depending on the usage of the medium. Growth was monitored until the plants were ready to be harvested.

<u>Nutritional quality</u>
The leaves of the silver beet and the fruits of the tomatoes were separated from the plant and washed with distilled water and the wet weight was analysed for total soluble solids (TSS), total carotenoids and ascorbic acid (vitamin C). Samples were analysed in triplicate. TSS was measured using an Atago digital pocket refractometer. Total carotenoids and ascorbic acid were estimated according to methods followed by Lalel (2002).

<u>Statistics</u>
To determine whether there was a significant difference between the media samples and the plant samples, results of the experiments were analysed using Independent-Samples T Test and One-Way ANOVA.

Results
The results given in Table 1 shows that there were no significant differences between the nutritional qualities of crops in all samples. The only difference was the total carotenoid between tomatoes grown in WW, CM and O. The total carotenoids concentration was significantly lower in the purchased organically grown tomatoes than those grown in WW and CM.

Table 1: Nutritional quality of silver beet and tomatoes grown in wastewater (WW), control medium (CM) and organically (O).

Nutritional quality (wet weight)	Silver beet			Tomatoes		
	WW	**CM**	**O**	**WW**	**CM**	**O**
Ascorbic acid (mg/100g)	20 ± 5	17 ± 1	21 ± 2	13 ± 3	21 ± 3	19 ± 4
Total carotenoids (mg/g)	687 ± 0	730 ± 28	700 ± 30	215 ± 24	281 ± 48	91 ± 11
Total soluble solids (% Brix)	7.4 ± 0.3	7.1 ± 2	< 4.5	5 ± 0.2	5 ± 0.5	6 ± 0.3

Discussion

Tomatoes are a popular fruit used all over the world as they are available year round and have lots of nutritional value, even when consumed in small quantities (Abushita et al., 2000). They are one of the highest contributors of vitamin C (Gahler et al., 2003; Wilcox et al., 2003). According to a study conducted by Abushita *et al* (2000), the mean ascorbic acid content in their tomatoes was 17mg/100g while, another study showed that greenhouse tomatoes have a vitamin C content of between 12-17mg/100g (Gahler *et al.* (2003). In this study, ascorbic acid concentration of the WW tomato (13mg/100g) was the lowest, however there was no significant difference between all the samples.

According to the USDA (2004), the ascorbic acid estimation in silver beet is 2.8mg/leaf and in tomatoes it is 15.6mg/tomato. This may be due to the amount of nitrogen available to them through the growth medium. It has been reported that an increase in nitrogen concentration decreases the ascorbic acid concentration in tomatoes, but it increases the concentration in spinaches (Wunderlich et al., 2007).

Lycopene (red carotenoid pigment) production in tomatoes is dependent on the potassium concentration (Zdravković et al., 2007). That study found that fertilisers with increased phosphorus did not significantly increase the level of lycopene. There was a significant difference ($p<0.05$) in total carotenoids between O tomatoes and both WW and CM tomatoes (Table 1). According to the USDA (2004), carotenoids estimation found in silver beet was 563μg/leaf and in tomatoes it was 552μg/tomato.

According to Nichols (2006), harvested tomato fruits have a Brix level of about 5%. However, TSS in wild tomatoes can reach 15%. According to the results in Table 1 fruits from both the WW and CM had the same Brix level of 5%. The tomatoes that had been purchased had a higher Brix level, however this was not statistically significant. Daiss *et al.* (2008) found that eight weeks after sowing silver beet in two treatments (EM-Bokashi+EM and Greengold®) they contained about 4.5 Brix and 4.3 Brix respectively. In this experiment the Brix levels in WW (7.4 Brix) and CM (7.1 Brix) were both higher (Table 1) than the organically purchased silver beet, which had low readings on the meter.

Nutritional quality of foods are important because without it, it can increase susceptibility to infection, reduction in academic performance, especially in children (United Nations., 2007). This study has shown that secondary treated domestic effluent can provide food crops with required nutrients for good nutritional value, which can positively influence the Millennium Development Goals.

Conclusion

According to this study, the silver beet and tomatoes grown in treated wastewater showed similar nutritional quality in terms of ascorbic acid, TSS and carotenoids as the commercial medium grown and organically grown produce. This highlights the potential for utilising secondary treated effluent for producing high-quality produce through hydroponics systems.

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