Analyzing the concentration of bioactive molecules in hydroponically grown plants

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Abstract

Hydroponics is a newly emerging concept of soil less cultivation of plants. In our current study, two common seasonal plants - Capsicum annuum and Foeniculum vulgare having different nutritional and economical benefits were grown by the hydroponic system and compared with the traditional system of growing plants in soil. It was found from our work that both the plants grown by the hydroponic system showed faster growth rate and higher yield.

A detailed analyses of the phytonutrient concentrations were done which revealed that all the principal bioactive molecules were significantly enhanced in the hydroponically grown plants as compared with the plants grown in soil pots. From the current work, we can conclude that hydroponics will be the forefront of horticulture as it will lead to naturally nutritionally enhanced produce in an economically viable methodology.

Keywords: Hydroponic system, ascorbic acid, carotenoid, flavonoid, phenol.

Introduction

The current need to produce food for a growing population, along with diminishing natural resources such as water and soil, demands newer and innovative methodologies. This technique facilitates cultivation where adequate land is scarce and in arid or barren conditions not conducive to propagation. Hydroponics is gardening without soil. By providing constant and readily available nutrition, hydroponics allows plants to grow up much faster than they do in soil[12]. *Capsicum annuum* (capsicum) and *Foeniculum vulgare* (fennel) have been found to grow well in indoor environment by hydroponic system.

The fruits of the plant *Capsicum annuum* (capsicum) are a rich source of many nutrients especially vitamin C. The fruits of the plant *Foeniculum vulgare* (fennel) offer a wide array of health benefits and may provide antioxidant, anti-inflammatory and antibacterial effects. Essential oil of the plant has been shown to contain more than 87 volatile compounds including the polyphenol antioxidants rosmarinic acid, chlorogenic acid, quercetin and apigenin[1]. These phytocompounds are active principles with therapeutic properties. Our present work studies the change in concentration of these bioactive molecules with alteration in the cultivation technology.

Material and Methods

Setting up of the system: The hydroponic system used was of the wick system type. The inert support media used was perlite. 10gm of organic compost was applied once in 15 days. The organic compost fertilizer comprised of the following components - vermicompost: neem cake: bone dust: kerameal in the ratio of 5:1:2:1. Small pots containing 2 kg of soil were taken.

Time of study: *Capsicum annuum* (capsicum) was grown from December to February and *Foeniculum vulgare* (fennel) was grown from April to June in confirmation with the natural growing season of the plants under tropical climatic conditions.

Sample of study: *Capsicum annuum* (capsicum) forms a part of many cuisines worldwide and fennel enhances the aroma of food apart from their other nutritive benefits.

Estimation of ascorbic acid: The sample extract was prepared by grinding the plant sample in 4% oxalic acid and titrating against the dye which is 2, 6 dichlorophenol indophenol.[11]

Estimation of total carbohydrate: The plant sample was acid digested and then neutralized with sodium carbonate, centrifuged and the supernatant was collected. To it anthrone was added, boiled, cooled and the absorbance was recorded at 630nm.[11]

Estimation of carotenoids: The sample was ground in 3% acetone and supernatant was collected for preparation of the sample extract. This was followed by addition of petroleum ether and distilled water to transfer the pigments to the petroleum ether phase. The absorbance was recorded at 452nm.[11]

Estimation of flavonoids: The plant material was boiled in water-ethanol solution 60% (v/v) for 60 min. It was then cooled and filtered. To the filtrate methanol, 2% $AlCl_3$ was added and incubated for 25 min. The absorbance was recorded at 430 nm.[4]

Estimation of total phenol: The sample extract was prepared by grinding the leaves in 80% ethanol and collecting the supernatant. To small aliquots, Folin

Ciocalteau reagent and sodium carbonate were added. The tubes were placed in boiling water, cooled and the absorbance was recorded at 650nm.[11]

Determination of iodine value: To the finely ground plant material was added chloroform, Hanus iodine solution and was incubated for 30 min. with constant shaking. To it was added potassium iodide solution and then titrated against 0.1 N sodium thiosulphate solution along with addition of few drops of starch solution.[11]

Statistical analysis: All experiments were conducted in triplicate, standard deviation was determined and students t-test at $p < 0.05$ was applied to find out statistical significance.

Results

Growth and yield: There was about double growth in length and girth of the plants growing in the hydroponic system as compared to that growing in the pots. As far as yield is focussed, the plants growing in the hydroponic system showed earliest appearance of flowers followed by fruits. The rate of watering the plants was every alternate day for potted plants whereas once per month in the hydroponic system which shows a great reduction in the water requirement.

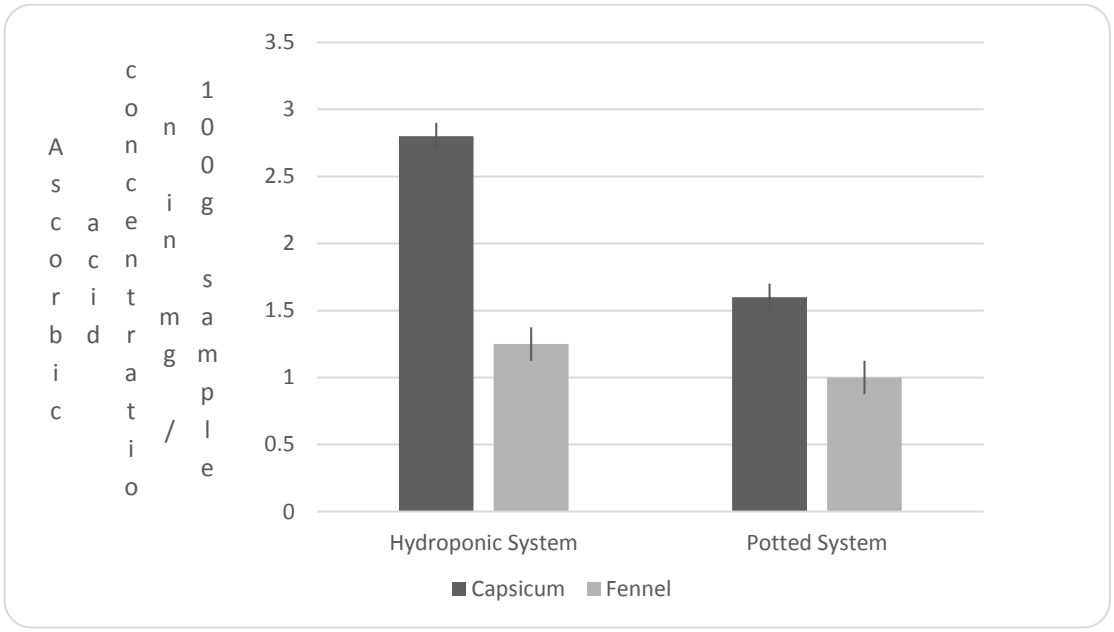

Fig. 1: Ascorbic acid content in fruits

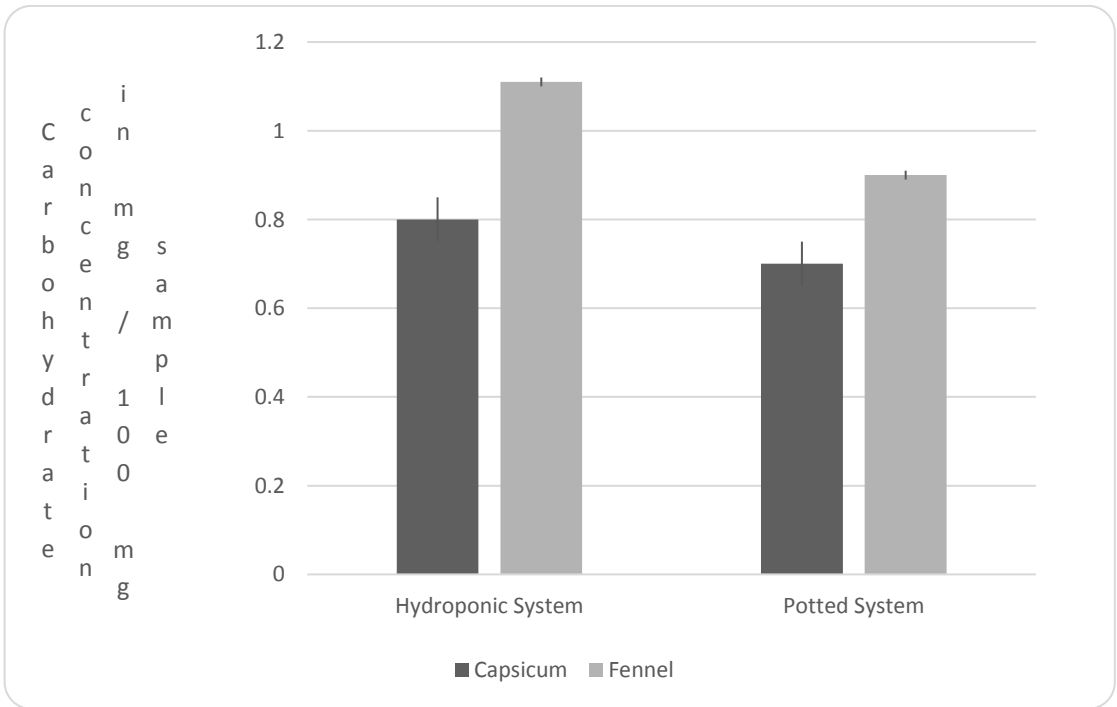

Fig. 2: Carbohydrate content in fruits

Estimation of ascorbic acid: For capsicum, the fruits of the plants grown by the hydroponic system showed an ascorbic acid concentration of 2.8mg / 100g sample compared to 1.6mg / 100g sample in the pot grown plants. For fennel, the fruits of the plants grown by the hydroponic system showed an ascorbic acid concentration of 1.25 mg / 100g sample compared to 1mg / 100g sample in the pot grown plants (Fig. 1).

Estimation of total carbohydrate: For capsicum, the fruits of the plants grown by the hydroponic system showed a total carbohydrate concentration of 0.8 mg / 100mg sample compared to 0.7 mg / 100mg sample in the pot grown plants. For fennel, the fruits of the plants grown by the hydroponic system showed an ascorbic acid concentration of 1.11mg / 100mg sample compared to 0.9mg / 100mg sample in the pot grown plants (Fig. 2).

Estimation of carotenoids: The capsicum fruits of the plants grown by the hydroponic system showed a total carotenoid concentration of 824.4 µg / 100g sample compared to 513.4 µg / 100g sample in the pot grown plants (Fig. 3).

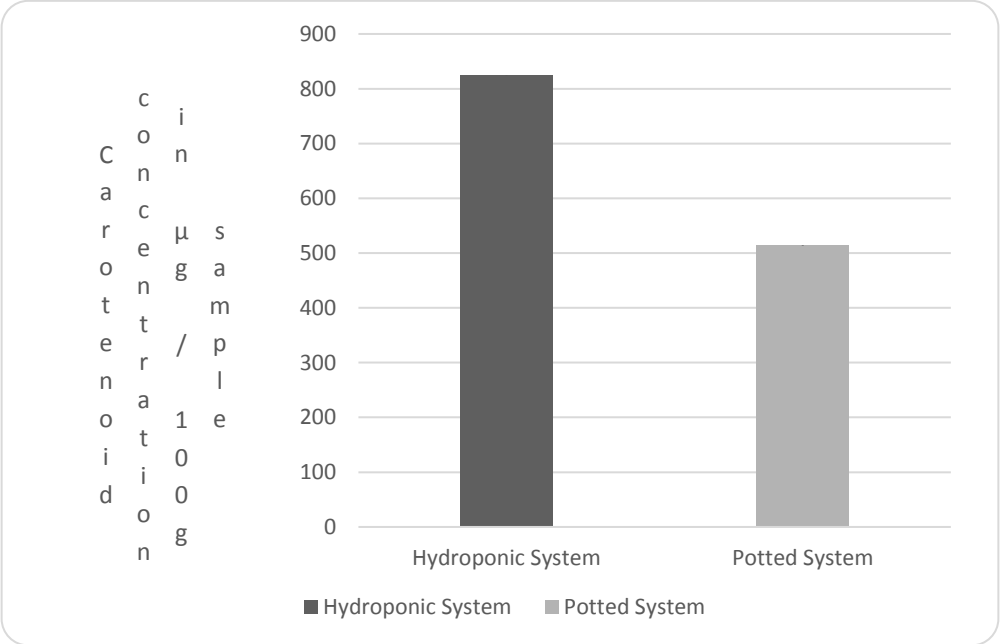

Fig. 3: Carotenoid content in fruits

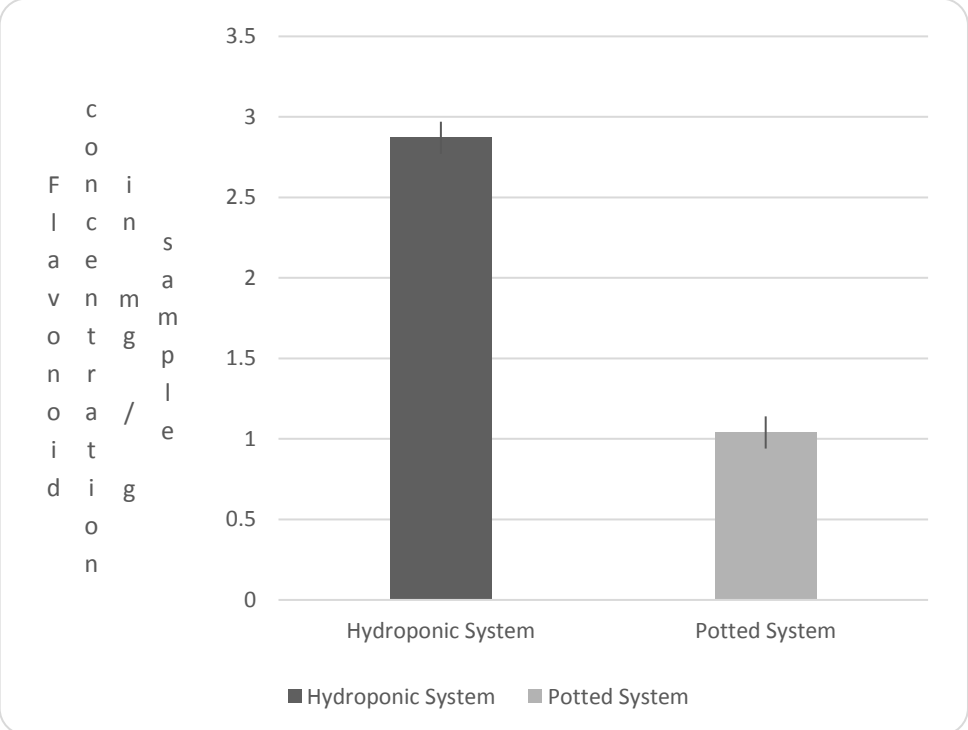

Fig. 4: Flavonoid content in fruits

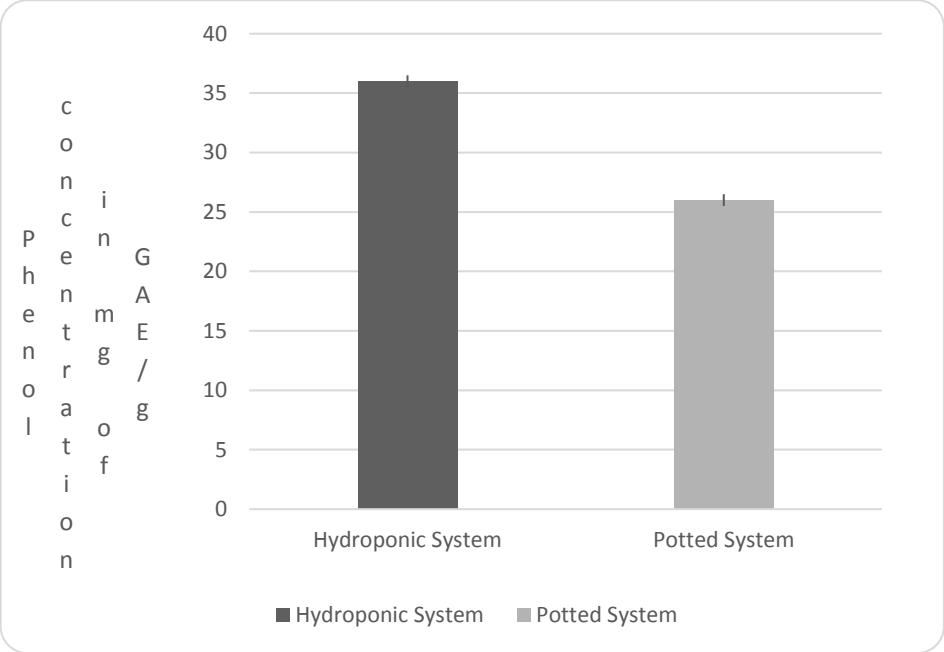

Fig. 5: Phenol content in fruits

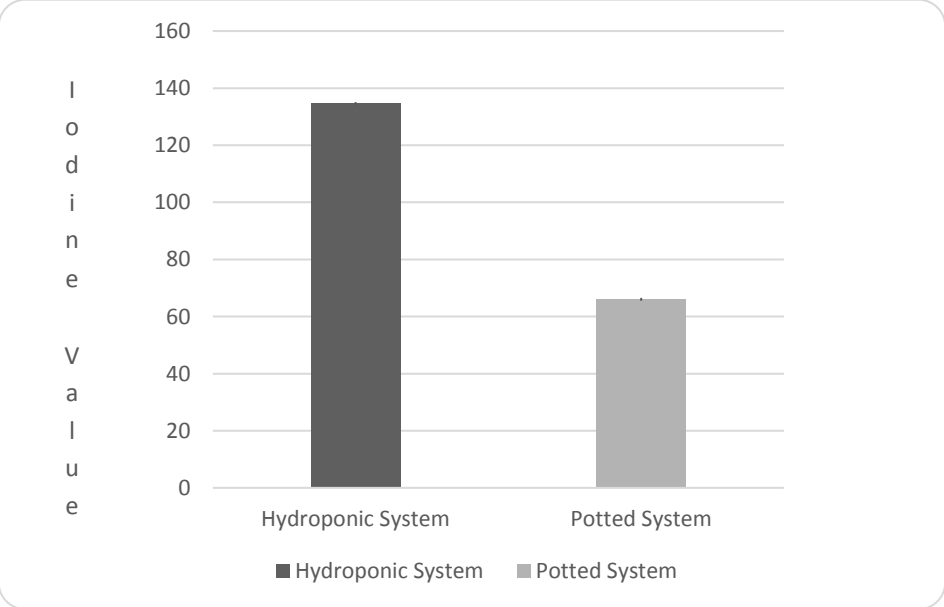

Fig. 6: Iodine value determination

Estimation of flavonoids: The capsicum fruits of the plants grown by the hydroponic system showed a total flavonoid concentration of 2.87 mg/g sample compared to 1.04 mg/g sample in the pot grown plants (Fig. 4).

Estimation of total phenol: The fennel fruits of the plants grown by the hydroponics system showed a total polyphenol concentration of 36 mg of GAE/g whereas the value for pot grown plants is 26 mg of GAE/g (Fig. 5)

Determination of iodine value: The fennel fruits of the plants grown by the hydroponics system showed an iodine value of 134.62 whereas the value for pot grown plants is 66.04 (Fig. 6).

Discussion

Growth and yield: The hydroponic system is a system which conserves water and regulates the nutrients which are more efficiently taken up by the plants. This results in two folds faster growth rate and higher yield of nutritionally enriched fruits as compared to the plants grown in soil containing pots.

Ascorbic acid content in fruits: Ascorbic acid is a potent reducing and antioxidant agent.[8] Capsicum grown by hydroponic system shows 1.75 fold increase and fennel shows 1.25 fold increase over potted plants.

Carbohydrate content in fruits: Dietary fibers help in maintaining bowel health, controlling blood sugar levels and

thus reducing the risk of type 2 diabetes.[5] Capsicum and Fennel are low glycemic food. Capsicum grown by hydroponic system shows 1.14 fold increase and fennel shows 1.23 fold increase over potted plants.

Carotenoid content in fruits: Carotenoids have been known to reduce oxidative stress[6], display anti tumor activity[7,13] and pretect against cardiovascular diseases[14]. Capsicum grown by hydroponic system shows 1.6 fold increase over potted plants.

Flavonoid content in fruits: Flavonoids are very useful as an antimicrobial agent, an antiulcer agent and as an antiangiogenic agent[2]. Capsicum grown by hydroponic system shows 2.76 fold increase over potted plants.

Phenol content in fruits: Essential oils of fennel contain a great amount of polyphenols, which are associated with the prevention of disease assumed to be induced by oxidative stress such as cardiovascular diseases, cancer and inflammation[9]. Fennel grown by hydroponic system shows 1.38 fold increase over potted plants.

Iodine value determination: Fennel oil is characterized by the high presence of monounsaturated fatty acids[10]. The greater is the iodine value, the higher is the essential oil content. Fennel grown by hydroponic system shows 2.04 fold increase over potted plants.

Conclusion

From our work it is observed that growing plants by the hydroponic system imbibes the benefits of soil and water conservation and is thus an example of sustainable mode of cultivation. Apart from this, it leads to increased concentration of phytonutrients. Phytonutrients helps in boosting the immune defense system and thus concluding that hydroponically grown plants have higher accumulation of bioactive molecules than traditionally pot grown plants.

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