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RESEARCH PAPER

A comparative study of sweet pepper fruits nutritional composition produced under conventional and organic systems

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Abstract : Consumers demand organic products because they believe they are more flavorful and respectful to the environment and human health. A plastichouseexperiment was carried out at Humrat Al-Sahen; about 15 km from As Salt-Jordan, During the 2010-2012 seasons; to compare the effect of four fermented organic matter sources (cow, poultry and sheep manure in addition to compost) in which 4 kg organic matter m^{-2} were used, with that of the conventional agriculture (chemical fertilizers) treatments on "Barotte"red pepper fruit quality, by using a randomized complete block design (RCBD) with four replicates. Conventional treatment influenced the total yield per replicate, produced the biggest fruit size, and the highest water content, lycopene and titratable acidity, while fruits characteristics cultivated in soil supplemented with manure were generally better than those from plants grown in soil only; addition of animal manure increased sweet pepper fruit content of soluble solids, ascorbic acid, total phenols, crude fibreand intensity of red color.In most cases of animal manure treatments, best results were obtained by sheep manure treatment that produced the highest TSS, while the worst results were obtained by the poultry manure treatment that produced the lowest fruit lycopene content and the smallest fruit size.

Key Words : Pepper, Yield, Compost, Phenols, Ascorbic acid, Lycopene

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INTRODUCTION

Sweet pepper (*Capsicum annum* L.), which belongs to the Solanacea family, is one of the most varied and widely used foods in the world; it was originated in the Mexico and Central America regions and Christopher Columbus encountered it in 1493 (Kelley and Boyhan, 2009). Consumer awareness of the relationship between foods and health, together with environmental concerns, has led to an increased demand for organically produced foods. Consumers demand organic products because they believe they are more flavorful and respectful to the environment and human health (Lopez *et al.*, 2007b). Fruit yield was significantly higher under chemical nutrients supply compared with organic nutrient supply (Appireddy *et al.*, 2008). Also, the comparison of different organic amendments and combined application of organic amendments, along with biofertilizers revealed that there was 25 - 46 % reduction in sweet pepper yield compared with conventionally produced peppers (Gopinath *et al.*, 2009).

A phenolic compound called capsaicin is responsible for the pungency in peppers. Pepper is grown as an annual crop due to its sensitivity to frost; pepper is actually a herbaceous perennial and will survive and yield for several years in tropical climates (Kelley and Boyhan, 2009; and Peet, 1995). One medium green sweet pepper can provide up to 8 per cent of the Recommended Daily Allowance of Vitamin A, 180 per cent of Vitamin C, 2 per cent of calcium and 2 per cent of iron (Kelley and Boyhan, 2009).

In general the public perceives organic foods as being healthier and safer than those produced through conventional agricultural practices (Jolly, 1989). Organic foods have a nutritional and/or sensory advantage when compared to their conventionally produced counterparts. Advocates for organic produce claim it contains fewer harmful chemicals, is better for the environment and may be more nutritious (Mitchell and Chassy, 2005).Sweet pepper fruits are an excellent source of health promoting substances, particularly antioxidants, ascorbic acid (vitamin C), polyphenols, carotenoids and sugars (Leja *et al.*, 2008; Howard *et al.*, 2000; and Jadczak *et al.*, 2010).

Red sweet peppers also contain lycopene which is a carotene that helps to protect against cancer disease (Lopez *et al.*, 2007a); lycopene was ranged from 0.18 – 0.36 mg/ 100 g f.wt. -depending upon cultivars-and was found to be higher in conventional agriculture than organically produced pepper (Hallmann and Rembialkowska, 2008)

The accessibility of nitrogen has the potential to influence the synthesis of phenolic antioxidants and soluble solids and there is a decrease in the concentration of phenolic antioxidants in plants with increasing nutrient availability (Doll, 1994). Organic red peppers could be considered as those having the highest antioxidant activity of all studied peppers compared to conventional one (Hallmann and Rembialkowska, 2008; and Lopez *et al.*, 2007b).

Addition of sheep manure increased sweet pepper fruit soluble solids content and decreased titratable acidity values compared to the unamended soil, while their pH was significantly lower. It was found that amounts and characteristics of pepper fruits from plants cultivated in soil supplemented with manure were generally better than those from plants grown in soil only (Liaven *et al.*, 2008).

Ascorbic acid, known as vitamin C, needs to be consumed via food or medicine, as it not produced in the human organism; it participates in nearly all chemical reactions that occur in human organism (Antoniali *et al.*, 2007). The levels of vitamin C, carotenoids and phenolic compounds in peppers depend on several factors, including cultivar, agricultural practices and maturity stage (Lopez *et al.*, 2007a). In a study conducted by Mitchell *et al.* (2007); vitamin C content was higher in organically produced vegetables in compare to conventionally produce, also Hallmann and Rembialkowska (2008) found that; organically produced sweet peppers contained significantly more vitamin C than conventionally grown fruits.

Environmental stresses are known to activate the bio-synthesis of phenolic compounds (Mitchell *et al.*, 2007). Differences between the content of phenolic metabolites in organically and conventionally produced fruits allow for the possibility that organically grown produce may benefit human health more than corresponding conventionally grown produce. Reviews of existing literature demonstrate inconsistent differences in the nutritional quality of conventionally and organically produced vegetables with the exception of potentially higher levels of certain minerals, ascorbic acid and less nitrates in organic foods (Woese, 1997; and Bourn and Prescott, 2002).

Organic farming provides peppers with the highest intensities of red and yellow colors, while conventional fruits were those with the lowestvalues of color intensity (Lopez *et al.*, 2007a; Lopez *et al.*, 2007b).Fertilization with K increased fruit acidity and decreased maturity index, so adequate management of fertilization with Ca and K could improve the yield and fruit quality of pepper; and the fruit quality measurements of pH (5.26-5.45), TSS (8.6-9.1 %), and TTA (0.21-0.24 %) were affected by the chemical fertilizers (Rubio *et al.*, 2010).

Vegetable growers in Jordan often use large amounts of chemicals in an attempt to improve and protect fruit quality and plant vigor, also, they apply manure to their soil either alone or in combination with mineral fertilizers. However, there is limited research on the effects of these organic amendments on fruit quality. The objectives of the study were to develop scientific data on sweet pepper (*Capsicum annum* L.) fruit quality in response to the application of different agricultural practices; conventional and organic.

MATERIAL AND METHODS

This study was conducted during the 2010-2012 seasons, under a plastichouse conditions at Station of Princess Tasneem Bent Ghazi for Technological Research in Humrat Al-Sahen; about 15 km from As Salt-Jordan. The climate in this region is rather hot and dry during summer, warm and rainy in winter.

Organic matter preparation and soil solarization:

Three months prior to transplanting, three different organic matter sources (cow, poultry and sheep manure) were fermented according to Preusch *et al.* (2004) recommendations. On the other hand during hot summer months (from August to October), soil solarization was done according to procedures outlined by Ames and Kuepper (2000).

Treatments applications:

A plastichouse was installed over the solarized area**,** the conventional planting was done according to the system applied in the farm were the experiment was conducted, and that included the use of fertilizers (50 kg ha^{-1} $week^{-1}$ of 20 N – 20 P – 20 K as fertigation and 118 kg ha^{-1} of ammonium nitrate as side dressing) according to recommendations of Russo and Veazie (2010) and Mitchell *et al.* (2007), and chemicals for pest control. For organic culture planting; four fermented organic matter sources were used;cow, poultry, sheep manure in addition to compost (which made from 1:1:1 mixture of the three organic matter sources in addition to different types of dry annual grasses), with amount of 4 kg m^{-2}. Barotte pepper cultivar was transplanted in October 2010, and experiment was finished by the end of May 2011. Then the experiment was repeated in the next season (2011/ 2012); same treatments were used in the same plastichouse locations with the same amounts and types.

Experimental design and statistical analysis:

Five treatments were conducted in a randomized complete block design with four replicates. All data obtained were statistically analyzed according to the design used in this experiment as outlined by Steel and Torrie (1980) and differences between treatment means were compared by using Least Significant Difference at 5 % significant level.

Parameters measured:

For measurements or analysis each season; the fruits were harvested at three time intervals during the experiment period; they were collected when green and fully grown, except for lycopeneand anthocyanin determination, its left until red color was completed, then at the end of the experiment average readings were considered for the two seasons.

Total yield:

This parameter was measured directly in the field by weighing the total freshly harvested fruits per replicate, using a digital scale balance. At the end of the experiments, all weights for each replicate were summed and divided by two.

Fruit size:

It was determined by water displacement method, average readings were expressed in cm^3 (Leskinen*et al.*, 2002).

Moisture content:

Fruits were taken from each replication, cut into pieces, dried in a forced air circulation oven at 70 ºC, until constant weight, results were expressed in percentage (Rubio *et al.*, 2010).

pH:

The fruits were liquefied and filtered for pH determinations; a digital pH-meter were used with the application of electrode directly in the blender pulp (Rubio *et al.*, 2010).

Total soluble solids (TSS):

A small sample of blender pulp was filtered, and then TSS in juice was determined by an Antago N1 benchrefractometer, results were expressed in percentage (Rubio *et al.*, 2010).

Total titratable acidity (TTA):

Determined by means of 10 g of pulp ground in a blender and homogenized with 90 ml distilled water. NaOH (0.11 mol L^{-1}) was used as a standardized titration solution of malic acid per 100 g of sample, and results were expressed in percentage (Antoniali *et al.*, 2007).

Anthocyanin:

Estimated by methods outlined by Abu-Zahra *et al.* (2007), and expressed as mg anthocyaninper 100 g of fruit fresh weight.

Lycopene content:

Fruit samples were blended with acetone, and then absorption spectra were measured by Spectrophotometer, results expressed as mg of lycopene per 100 g of fruit fresh weight, according to procedure outlined byCaller and Machinney (1965).

Crude fibre:

Estimated by methods outlined by Abu-Zahra *et al.* (2007), and expressed as percentage.

Ascorbic acid (Vitamin C):

Determined by the titratability of 3 g of the blended pulp homogenized with 50 ml of oxalic acid at concentration of 12 %. The titratable solution consisted of 2.6 sodium indophenols dichlorophenol. Results were expressed in mg of ascorbic acid per 100 g of pulp (Antoniali *et al.*, 2007).

Total phenolics:

Detected by the photometric method with Folin's reagent according to Leja *et al.* (2008) and Abu-Zahra *et al.* (2007), results were expressed in mg total phenols per 100 g of fruit fresh weight.

RESULTS AND DISCUSSION

The results obtained from the present investigation as well as relevant discussion have been summarized under following heads :

Total yield per replicate:

The highest total yield per replicate (48.22 kg) was obtained by the conventional treatment which significantly exceeded all other treatments (Table 1), while the lowest total yield was obtained by the cow manure treatment (37.73 kg). The highest yield obtained by the conventional treatment could be due to the supply of inorganic fertilizers. On the other hand the low availability and the slow release of nutrients from the organic matter, is supposed to be responsible for the low yield in the organic treatments compared to the conventional treatment (Jadczak *et al.*, 2010). These data correspond with the results obtained byPalomaki*et al*. (2002); Appireddy*et al*. (2008) and Gopinath*et al*. (2009), whom found a decrease in average yield under organic culture compared to conventional growing methods.

Table 1.Results of Sweet pepper fruitstotal production, size, moisture content, pH, TSS and TTA*

Fruit pH	Moisture content (%)	Fruit size (cm^3)	Total production (kg/rep)	Treatments
4.97 a	92.6 a	190.5 a	48.22 a**	Conventional
5.06 a	91.0ab	184.7ab	42.07 b	Sheep manure
5.06 a	88.1 b	175.7 bc	37.73 c	Cow manure
5.00 a	89.3ab	168.5 c	40.78bc	Poultry manure
4.86 a	91.4ab	179.6 b	39.48 bc	Compost

*: Values are the mean of four replicates.
**: Means within each column having different letters are significantly different according to LSD at 5 % level.

Fruit size:

Fruit size ranged from 152.5 cm^3 - 172.34 cm^3 (Table 1). The conventional treatment resulted in the significantly biggest fruit, compared to all other treatments, which may be due to the good availability of soil nutrients that produced healthy plants with large vegetative growth that reflected in the yield and fruit size. While the large fruit size in the sheep manure treatment may be due to the good improvement of soil physical and chemical conditions. On the other hand the smallest fruit were obtained by the poultry manure treatment, without being significantly different from the cow manure treatment, which could be due to the low availability of soil nutrients and unproven soil physical conditions.

Moisture content:

Fruit moisture content ranged from 87.60 – 92.05 % (Table 1), the used of animal manure was found to decrease the water content of the fruits, which reflected in increasing fruit dry matter, but this decrease is only significant with the cow manure which produced the lowest fruit water content in compare to the conventional treatment which produced the highest water content.

pH:

Results of Marvello pepper cultivar fruit pH (Table 1) do not show any significant differences between all the used treatments. Fruit pH was ranged from 4.63 to 4.82, which do not locate within ranges obtained by Rubio *et al.* (2010). Also our results do not coincide with Liaven *et al.* (2008); who found that the addition of sheep manure significantly lowered the fruit pH.

Total soluble solids (TSS):

Addition of animal manure improved sweet pepper fruit taste by increasing the fruit soluble solids content in compare to the conventional produced fruit (Fig. 1), the TSS percentage found in fruit of all treatments was relatively low and ranged from 5.21 to 6.66 % in compare to that obtained by Rubio *et al.* (2010), which could be due to differences between the used cultivars. The lowest TSS % was obtained by the conventional treatment, while the highest was obtained by the sheep manure treatment. These results are in agreement with those obtained by Cayuela *et al.* (1997).

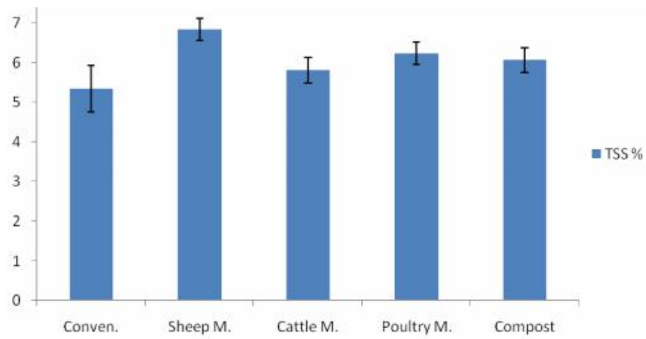

Fig. 1 : **Results of sweet pepper fruit TSS %**

Total titratable acidity (TTA):

The TTA percentages found in all treatments were relatively low and ranged from 0.131 to 0.192 % (Fig. 2), which is lower than that obtained by Rubio *et al.* (2010)due to differences in the used cultivars. Addition of animal manures decreased sweet pepper fruit titratable acidity values compared to the unamend soil; the lowest titratable acidity was obtained by the sheep manure treated pepper fruits, while the highest was obtained by the conventional treatment which does not show a significant difference with the compost treatment. These results showed an opposite trend to fruit soluble solids content, and in agreement with Liaven *et al.* (2008) results.

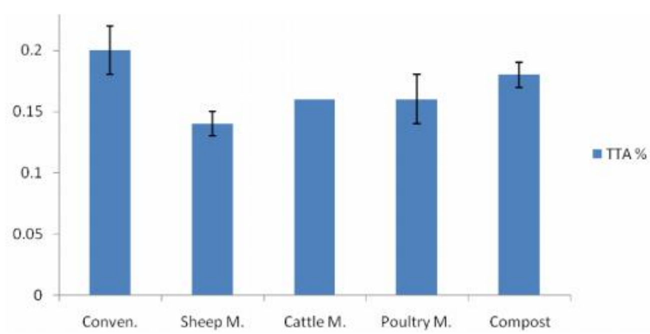

Fig. 2 : **Results of sweet pepper fruit TTA %**

Anthocyanin content:

The highest anthocyanin (38.54 mg 100 g^{-1}) amount was obtained by the compost organic matter treatment (Fig. 3), without being significantly different from all other organic matter treatments. The least anthocyanin content was obtained by the conventional treatment, which was significantly lower than compost and poultry organic matter treatments.These results are in agreement with results obtained by Cayuela *et al.* (1997),Lopez *et al.*(2007a), and Lopez *et al.* (2007b) in which organic farming provides peppers with the highest intensities of red and yellow colors, while conventional fruits were those with the lowest values of color intensity.

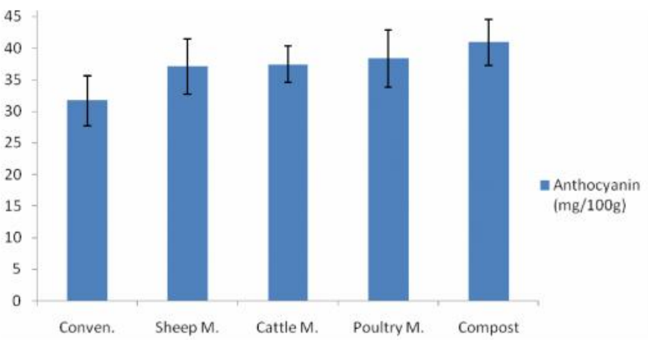

Fig. 3 : **Results of sweet pepper fruit anthocyanin content (mg/100g)**

Lycopene content :

Results of lycopene (Fig. 4) was ranged from 0.271 – 0.450 mg 100 g^{-1}, the highest lycopene amount was obtained by the conventional agriculture, without being significantly different from the cow and or compost treatments. On the other hand the lowest fruit lycopene was obtained by the poultry manure treated pepper fruits, with a significant difference from all of the used treatments. These results are in agreement with that obtained byHallmann and Rembialkowska, (2008), and within the obtained lycopene ranges. Therefore, organic treatments do not improve fruit lycopene content in compare to conventional agriculture that hastened fruit lycopene content.

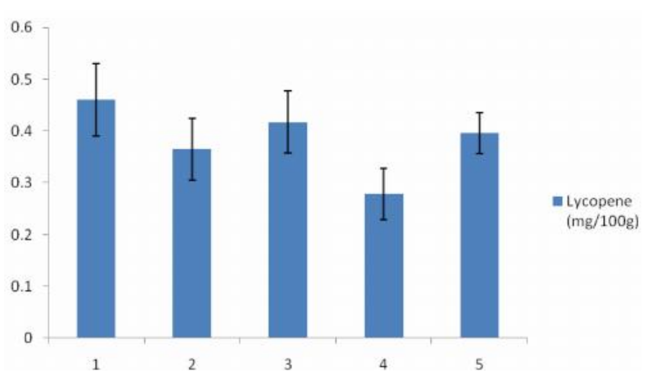

Fig. 4 : **Results of sweet pepper fruit lycopene content (mg/100g)**

Crude fibre:

Results of Fig. 5, shows that crude fibre was improved only by the use of the cow manure, which produced the highest (2.96 %) crude fibre content. No statistically differences were observed between all other treatments, eventhough the lowest (2.18 %) crude fibre content was obtained by the conventional treatment.

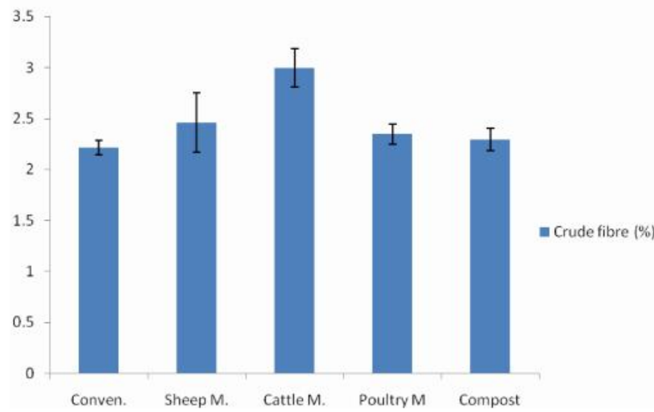

Fig. 5 : **Results of sweet pepper fruit crude fibre content (%)**

Ascorbic acid content (Vitamin C):

Sweet pepper fruits are an excellent source of vitamin C, since high amounts were obtained from all of the used treatments that ranged from 137.25-168.75 mg100 g^{-1} (Fig. 6), and in agreement with results obtained by Jadczak *et al.* (2010). The highest amount of vitamin C, was obtained from the sheep manure, while the lowest amount was obtained by the conventional agriculture, although without being significantly different from the cow manure treatment. These results are, to some extent, in agreement with those reported by Cayuela *et al.* (1997).

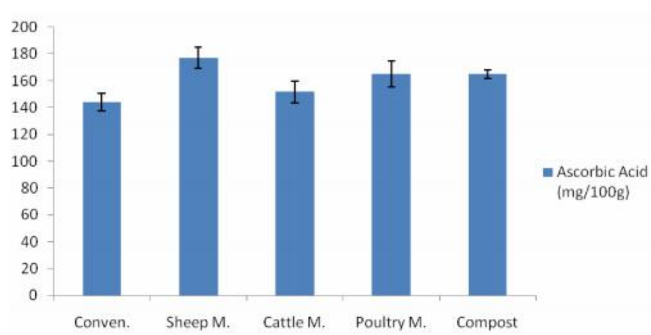

Fig. 6 : **Results of sweet pepper fruit ascorbic acid (mg/100g)**

Total phenolics:

Organic matter treatments had significantly more total phenols than the conventional system (Fig. 7); the highest (1458 mg 100 g^{-1}) content was obtained by the sheep organic treatment, on the other hand same level of significance were observed from sheep, poultry and compost treatments. These results are in agreement with those reported by Leja *et al.* (2008). The low content of phenolic compounds in the conventional agriculture is due to increase availability of plant nutrients mainly nitrogen (Doll, 1994). Otherwise the restricted uses of chemicals were reported to accelerate synthesis of phenolic compounds in organic production (Hakkinen and Torronen, 2000).

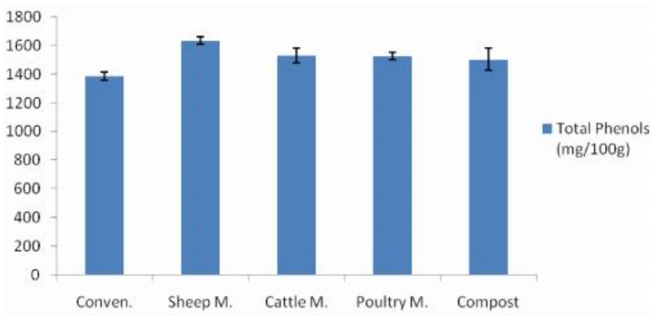

Fig. 7 : **Results of sweet pepper fruit total phenols (mg/100g)**

Conclusion:

Conventional treatment influenced pepper fruit yield per replicate, butit was found that fruits characteristics from plants cultivated in soil supplemented with manure were generally better than those from plants grown in soil only. Addition of animal manure increased sweet pepper fruit content of soluble solids, ascorbic acid, total phenols, crude fibre and intensity of red color in compare to conventional agriculture that produced fruits with higher titratable acidity, water content, lycopene, and bigger fruit size. Fruit pH do not affected by the organic matter treatments or conventional agriculture.

In most cases of animal manure treatments;best results were obtained by the sheep manure treatment that produced the highest TSS, whilethe worst results were obtained by the poultry manure treatment that produced the smallest fruit and lowest fruit lycopene content.

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