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Chapter 16

Quality and Nutrient Contents of Fruits Produced Under Organic Conditions

Taleb Rateb Abu-Zahra

Additional information is available at the end of the chapter

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Abstract

Organic farming is an agricultural practice that raises plants especially vegetables and fruits without the use of synthetic pesticides, herbicides, fertilizers, or plant growth regulators. All over the world, the interest for organic farming has increased recently. Different greenhouse experiments were carried out in the northern Jordan Valley, to compare the effect of four fermented organic matter doses (1.5, 3.0, 4.5, and 6.0 kg m^{-2}), or different organic matter sources (cattle, poultry, and sheep manure in addition to 1:1:1 mixture of the three organic matter sources) with that of the conventional fertilizer and control treatments on different fruit quality parameters.

Results obtained showed that fruit titratable acidity (TA) percentage, size, moisture content, and ammonium and nitrate contents were higher in the conventionally produced fruits in comparison to the organically produced fruits. The organic treatments tended to produce fruits with higher anthocyanin, total soluble solids (TSS) percentage, dry matter content, ascorbic acid, total phenols, and crude fibre content in comparison to the control and conventionally produced fruits. In most cases, sheep manure source and 4.5 kg O.M m^{-2} treatment amount produced the best results.

Keywords: Nutrients, pigments, quality

1. Introduction

1.1. Environmental Issues

Environmental issues are capturing more and more of the world's attention; therefore, researchers and scientists are aiming at improving environmental quality through the

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adoption of techniques and measures that have a reduced impact on the environment [1]. Conventional agriculture practices utilize high-yield crop cultivars, chemical fertilizers and pesticides, irrigation techniques, and mechanization that have a huge impact on our environment [2]. Plants are subjected to attack by a large and diverse number of pathogens and pests; as a result, crop producers often use large amounts of agrochemicals in an attempt to improve and protect the fruit quality and plant vigor [3]. Ever since people have become aware that health is linked to health environment, the control and reduction of pollution have become the focus of worldwide concern [4]. Pollution is becoming a serious problem in agricultural regions; for example, various mineral fertilizers and agrochemicals lead to pollution and serious health problems in humans, hence alternative production techniques which employ biological or organic compounds for disease and pest control are needed [5]. In addition to the human health concern of elevated heavy metal concentrations in soil, they can cause harm to native ecosystem and accumulation in plant tissue can result in damage to wildlife [6]. Plant toxicity is the primary concern for elevated zinc concentration in soil, whereas the potential for risk to the herbivores is the primary concern with elevated cadmium concentration in soil, while human health concerns focus on lead concentration for which the most pertinent pathway is direct ingestion of soil [7].

1.2. Organic culture

Organic farming, which essentially excludes the use of many inputs associated with modern farming, most notably synthetic pesticides and fertilizers, is becoming more and more popular worldwide [2, 8]. Consumer's awareness of the relationship between foods and health, together with environment concerns, has led to an increased demand for organically produced foods. In general, the public perceives organic foods as being healthier and safer than those produced through conventional agricultural practices [9]. Consumers demand organic products because they believe they are more favorable and respectful to the environment and human health [10]. Organic foods have a nutritional and sensory advantage in comparison to their conventionally produced counterparts. Advocates for organic produce claim that it contains fewer harmful chemicals, is better for the environment, and may be more nutritious [11].

2. Fruit nutrient contents

2.1. Mineral contents

Mineral contents of fruits were found to be higher in fruits produced under conventional systems in comparison to the fruits produced under organic systems [12]. For example, bell pepper fruits, which were produced under conventional systems, were characterized by a high content of minerals (Table 1). The highest contents of zinc and iron in bell pepper were obtained in the conventional treatment with significant differences between other treatments, while there were no significant differences among the organic matter treatments, which could be attributed to the high application of chemical fertilizers [13].

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Treatments	Zinc content (ppm)	Iron content (ppm)
Conventional	1.410 a	57.75 a
Cattle manure	1.170 b	45.50 b
Poultry manure	1.163 b	39.75 c
Sheep manure	1.165 b	39.25 c
Mixture manure	1.227 b	42.75 bc

*Means within each column having different letters are significantly different according to Least Significant Difference at 5% level.

Table 1. Effect of culture systems on contents of zinc and iron in bell pepper fruit

The contents of calcium, magnesium, sodium, potassium, and phosphorous in bell pepper fruit were significantly higher in those produced with conventional system than all those produced with organic matter systems (Table 2); even though the highest calcium content was obtained by the conventional treatment, there was no significant difference with the poultry manure, which could be due to the high use of limestone in the chicken food mixture [13].

Treatments	Calcium (mg 100 g^{-1})	Magnesium (mg 100 g^{-1})	Phosphorus (mg 100 g^{-1})	Sodium (mg 100 g^{-1})	Potassium (mg 100 g^{-1})
Conventional	260 a	89.25 a	394 a	26.1 a	2323 a
Cattle manure	243 b	79.50 b	315 b	19.1 b	1889 bc
Poultry manure	257 a	81.75 ab	362 ab	19.9 b	1820 c
Sheep manure	239 b	84.50 ab	349 ab	18.1 b	1986 b
Mixture manure	246 b	77.75 b	348 ab	19.6 b	1915 bc

*Means within each column having different letters are significantly different according to Least Significant Difference at 5% level.

Table 2. Effect of culture systems on contents of calcium, magnesium, phosphorus, sodium, and potassium in bell pepper fruit

2.2. Ammonium and nitrate

Vegetables represent the most important source of nitrogen for human nutrition, which is essential for growth. Therefore, its accumulation in plants is a natural phenomenon resulting from uptake of the nitrate ion that is found in excess amounts, and the intensive use of nitrogen fertilizer and manure causes nitrate contamination of the environment; therefore, vegetables can accumulate high levels of nitrogen and, when consumed, pose serious health concerns [13]. Ammonium and nitrate contents in conventionally grown strawberry fruits were 49.4 and 23.6 ppm, respectively, due to high use of inorganic nitrogen fertilizers, whereas it was found that ammonium content was 32.3 ppm and nitrate content was extremely low in organically

produced fruits [10]. The nitrate content in bell pepper fruit was very low (<200 $mgkg^{-1}$), for all different cultural systems (organic or inorganic), even though the minimum value of nitrate content for organically produced bell peppers and the maximum value for fertilized bell peppers were found below the safe limit [13].

3. Fruit quality

3.1. Total soluble solids and titratable acidity

All organically produced fruits had significantly higher total soluble solids (TSS) and lower titratable acidity (TA) in comparison to the conventionally produced fruits [5, 14]; for example, sensory attributes are important aspects of fruit quality, and the balance between sweetness and sourness are the most important determinants of overall quality of fruits [15]; for example, acceptance of the flavor quality of strawberry fruits is minimum 7% for TSS content, while the maximum is 0.8% for TA [16]. Organically grown strawberries had significantly higher TSS (7.1%) and lower TA content (0.93%) in comparison to the conventionally grown strawberries that had 6.6% TSS and 0.99% TA. On the other hand, addition of animal manure improved bell pepper fruit taste by increasing the percentage of TSS and the addition of animal manure decreased the percentage of TA in bell pepper fruit [10].

3.2. Total phenols

Phenolic metabolites may suit human health and contribute to the prevention of chronic diseases such as cancer and cardiovascular diseases [17]. In addition, phenolic compounds play a vital role in plant defense mechanisms against insect, fungi, and animal herbivores [18]. Levels of phenolic compounds were higher in organically grown fruits than the levels in conventionally produced fruits, because the restricted use of herbicides, pesticides, insecticides, and chemical fertilizers was reported to accelerate synthesis of phenolic compounds in organically produced fruits [19].

3.3. Ascorbic acid (Vitamin C)

Ascorbic acid content in fruits is cultivar dependent according to Leskinen et al. [20]; levels of ascorbic acid in organically produced fruits were consistently higher than the levels in the conventionally grown ones [8]. The highest fruit ascorbic acid content (50.5 mg 100 g^{-1} fruit fresh weight) was obtained by the organically treated berry fruits, whereas the conventional treatment gave the lowest ascorbic acid content (41.25 mg 100 g^{-1} g fruit fresh weight), according to Abu-Zahra et al. [10]. On the other hand, Cayuela et al. [14] did not find significant difference in the ascorbic acid content between organic and conventional grown strawberry fruits. Also manure type has an effect; the highest amount of vitamin C was obtained from the sheep manure–treated pepper fruits, while the lowest amount was obtained by the conventionally produced pepper fruits [10].

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3.4. Crude fiber

Fruit crude fiber content highly differs according to fruit dry weight [21], but it is found to be higher in organically produced fruits in comparison to conventionally produced fruits [10]; the high crude fiber content in the organically produced fruits could ensure better nutritional and health benefits related to fiber consumption [22]. The highest strawberry crude fibre fruit value (8.13%) was obtained by the 4.5 kg organic matter/m^2, which was significantly different from the conventional, and control treatments [13]. Although, crude fiber of bell pepper fruit was improved by the use of the cattle manure which produced the highest (2.96%) crude fiber content in comparison to the conventional system which produced the lowest content (2.8%) [23].

3.5. Fruit size

Fruit size is highly affected by the farming systems; the conventional agriculture resulted in the biggest fruits, in comparison to organically produced fruits. The large fruit size in the conventional farming system may be due to the good availability of soil nutrients that produced vigorous plants with higher yield and larger fruits. But it was observed that the use of high amount of organic matter (6 kg O.M/m^2) produced a large fruit size, which may be due to the good improvement of physical and chemical properties of the soil [10, 24].

3.6. Fruit fresh weight

Fruit weight depends on cultivar and temperature rather than on the culture system (organic or conventional) [10]. Moreover, most researchers found only small and non-significant differences between organic and conventional systems in respect to fruit weight [20]. But in an experiment conducted on strawberry plants, they observed that the use of chemical fertilizers were found to produce the highest significant average fruit weight compared to fruits produced by using organic materials or without using any type of fertilizers [10, 25].

3.7. Fruit moisture content and dry weight

Fruit moisture content showed an opposite trend to fruit dry matter content; organically produced fruits had more dry matter and lower water content in comparison to the conventionally produced ones. The decrease in fruit water content of the organically produced fruits was reflected on increasing fruit dry matter content in comparison to the conventionally produced fruits that produced the lowest fruit dry matter and highest water content [10]. For example, the highest strawberry moisture content (93.37%) was obtained by the conventional system which produced the lowest fruit dry matter content (6.63%), while strawberry fruits that are produced under organic systems, contains 92.61% moisture content and 7.39% of dry matter content [10].

3.8. Fruit pH

The fruit taste is highly affected by the fruit pH; addition of organic materials was found to lower the strawberry fruit pH, especially by using sheep manure as a source of organic matter

[24]. However, in an experiment conducted on pepper plant, results do not show any significant differences between all of the used organic and inorganic treatments on fruit pH [23].

4. Fruit pigments

4.1. Chlorophyll

Chlorophyll content of the leaves was increased by the use of organic matter applications; the highest increase was obtained by using the sheep manure as a source of organic matter, while the lowest amounts of leaf chlorophyll content were obtained by the use of chemical fertilizers [26].

A promotional effect of organic matter treatments on chlorophyll contents might be attributed to the fact that nitrogen is a constituent of chlorophyll molecule [3]; moreover, nitrogen is the main constituent of all amino acids in protein and lipids that act as a structural compound of the chloroplast. Contradictory data about the relationship between growth and chlorophyll content of leaves have been reported in which bio-fertilizers increased the content of photosynthetic pigments [27].

4.2. Anthocyanin

Organically grown fruits developed a significantly stronger color than conventionally grown ones [14]. The highest anthocyanin content of strawberry fruits (42.88 mg 100 g^{-1}fruit fresh weight) was obtained by the 6 kg O.M/m^2 treatment, while the least anthocyanin content was obtained by the control treatment (neither synthetic fertilizers nor organic materials). In spite of that, the anthocyanin content of the control treatment of strawberry plants remained within the ranges between 17.8 and 41.8 mg 100 g^{-1}, and values lower or higher than that range should not be acceptable [10].

In another study conducted on red pepper fruits, the highest anthocyanin (38.5 mg 100 g^{-1}) amount was obtained by the mixture of different organic matter treatment. And the least anthocyanic content was obtained by the conventional culture system, which proves that organic farming provides peppers with the highest intensities of red and yellow colors, while the conventional fruits were those with the lowest values of color intensity [23].

4.3. Lycopene

It is recorded that fruit lycopene content was the highest in conventional agriculture, but without significant differences from the different organic matter sources. Also fruit lycopene was affected by the organic matter source, and the lowest lycopene content was obtained by the poultry manure source–treated pepper fruits, which means lycopene fruit content does not improve by the use of organic matter treatments in comparison to conventional agriculture that hastened fruit lycopene content [23].

5. Conclusions

Fruit characteristics from plants cultivated in soil supplemented with animal manure were generally better than those from plants grown in soils only or supplemented with chemical fertilizers. In most cases of animal manure sources, sheep manure gave the best results. On the other hand, the use of chemical fertilizers was found to increase the fruit lycopene content and improve fruit size and yield by increasing the fruit weight. Organic foods contain fewer harmful chemicals, are better for the environment, and may be more nutritious.

Author details

Taleb Rateb Abu-Zahra

Address all correspondence to: talebabu@yahoo.com

Department of Plant Production and Protection, Faculty of Agricultural Technology, Al-Balqa Applied University, As-Salt, Jordan

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