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Quality Enhancement of Fruits and Vegetables through Organic Cultivation: A Review

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ABSTRACT

Organic farming, which essentially excludes the use of synthetic pesticides and fertilizers, is becoming popular worldwide. The covid-19 pandemic has positively impacted on the market due to growing awareness towards the healthy and nutritional diets. As a result, demand for organic fruits and vegetables has increased over the world. Organic fruits and vegetables are in higher demand than ever before, owing to lower production and rising global consumption. However, due to the high cost of production, organic fruit and vegetable supply is limited in comparison to demand. Several experiments were conducted for comparing the organic and conventional fruits and vegetables quality. The results obtained from the studies showed Vitamins like ascorbic acid and beta carotene, Total polyphenols, dry matter accumulation, fiber content and Total Soluble Solids were higher in organic fruits and vegetables than conventional farming. Other mineral nutrient contents like Ca, Mg, K, Cu, Fe, Zn, PO_4, SO_4 were found similar both in organic and conventional farm produce. Cooking of organic vegetables at high temperatures is not preferable because it shows higher polyphenols losses during cooking than conventional produces. Heavy metals contamination, pesticide residues, ammonium and nitrate contents were lower in organic produce than conventional crops. Organic foods are better for the environment and more nutritious. It can be concluded that organic crops have a lower amount of contaminants, but a higher quality compared to conventional crops.

Key words: Organic fruits and vegetables, Post-harvest performance, Quality at harvest.

Organic farming is a set of agricultural practices that focus on growing food through natural ecosystem management instead of synthetic outside inputs. Although it is often referred to as “alternative farming,” organic farming is actually a more traditional form of agriculture than much of modern-day farming. During the decade of the nineties, the interest in organics began to creep into the mainstream consumer purchases. Currently, there appears to be an influx of business-oriented producers into the organic production field. These individuals view organics more of a marketing strategy than a life style choice or belief (Conti *et al*., 2014). Consequently, large-scale agriculture has begun to take notice. Though India’s green revolution transformed it from a “begging bowl” to a self-sufficient nation both in agriculture and horticulture with increased use of synthetic agrochemicals such as fertilisers and pesticides, the adoption of nutrient-responsive high-yielding crop varieties and greater exploitation of irrigation potential, the continued use of these high-energy inputs has indiscriminately deteriorated soil health and the environment andfood safety has become a major concern. Overuse of agrochemicals has raised concerns about horticulture’s long-term viability, highlighting the importance of sustainable production approaches that meet health concerns of human beings. Organic fruit and vegetable production is a system based on the concept of environmental responsibility, which includes all forms of life. Globally, area under organic farming is increased from 2004 (21.89 million ha) to 2018 (71.08 million ha) and in India about 1.94 million ha of farmland was under organic cultivation (FAO, 2020). The increasing popularity of organic fruits and vegetables is, in a large part, due to the belief that food produced with this method of farming is free of pesticides and has greater nutritive value than conventionally produced fruits and vegetables (Oliveira *et al*., 2010). Concerns about food quality and safety, as well as environmental protection, sparked demand for organic products, which became the driving force behind the growth of organic agriculture. Also, organic products are expanding at a quicker rate (20-25%) than conventional products (5%) on a yearly basis. Farmers must be educated on the scientific ways of organic farming in order for their income to steadily rise. Organic farming is also chosen due to rising consumer demand for safe, high-quality organic foods that are also ethical. The quality enhancement of fruits and vegetables by organic cultivation is studied critically in this review.

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Status of organic vegetables and fruits in India

India Rank 8th in world’s organic agricultural land and rank first in total number of producers (FIBL and IFOAM Year

Book, 2020). Currently, India ranks 33rd in terms of total land under organic cultivation and 88th in agricultural land under organic crop to total framing area. Area under organic farming in India is around 3.67 million ha (2019-20). India has a lot of potential for producing a wide range of organic products and it produced around 3496800.34 MT (2020-21) of organic products with the total volume of export during 2020-21 was 888179.68 MT (APEDA). The production of fruits and vegetables was 67,350 MT in the year of 2020 - 2021 with per capita availability of 172 and 318 gm/day respectively (APEDA, Statista 2014). The general recommendation for intake of fruits and vegetables is atleast 400 grams per person per day. Similarly, national nutrition guidelines recommend avg. daily consumption of 300 g for vegetables and 100 g of fruits (World health organization, 2003). Average consumption of fruits and vegetables in India reported as 265 gm/day (Gupta *et al.*, 2012). Organic fruits and vegetables are safer to consume than the non-organic ones due to lower nitrate and cadmium content; and lesser pesticide residues. Worldwide only 0.7% of the organic land was devoted to the cultivation of vegetables, while India offered 14.3% of its organic area for vegetable cultivation.

Quality enhancement of fruits

Quality parameters at harvest

Nutrient content

Minerals

It is scientifically proven fact that minerals are an essential component of the human body, yet the body does not produce a single mineral element. This is why it is so important to eat fruits and vegetables because they contain minerals such as Ca, Mg, K and Zn. According to Institute of Medicine, Washington (USA) the average person should consume up to 7000 g/day of minerals in their diet (Ross *et al.,* 2011). There were no significant effects of production system on mineral composition (Ca, Mg, K, Fe, Cu, Zn, Cl, PO_4^{3-} and SO_4^{2-}) of fruits tabulated in Table 1 (Conti *et al.*, 2014).

Ammonium and nitrate

Conti *et al.*, 2014 reported that farming did not affect the mineral composition in annual and biennial strawberry. But the production method had an impact on ammonium and nitrates content was significantly higher in conventional farming over organic strawberry. With the exception of nitrates, which were higher in berries grown under conventional farming, the farming had no effect on the mineral composition of the fruit presented in Table 1.

Total soluble solids (TSS) and total acidity (TA)

Total soluble solids/sugar content includes the carbohydrates, organic acids, proteins, fats and minerals of fruits. It varies from 10-20% of the fruit fresh weight and it increases as fruit matures to produce less acidic, sweeter fruit. It is important that the grower aims to produce an acceptable balance of TSS and fruit acidity. Soluble solid content is a parameter used as an indicator of quality of fruits destined for industrial processing. Thus, industry prefers fruits with TSS values more than 13° brix, as a higher soluble solid content allows greater flexibility for addition of sugar during preparation for ready for consumption beverages, besides creating conditions that hinder microorganism growth.

Total acidity is a measure of the amount of acid present in a solution. It is an important parameter in determining fruit maturity and sour taste in fruit. Conti *et al.* (2014) made differences between organic and conventional farming. The organic management resulted in higher values of soluble solids and lower values of titratable acidity content. These findings were agreement with Oliveira *et al.* (2010) he showed that the soluble solid content (SS) increased during passion fruit ripening for both cropping systems. Results presented in Table 1 shows that organic passion fruits were sweeter (18.23°Brix) and less acid than conventional ones. In organic fruit, there was a delay in commercial harvest stage and higher values of TA and SS, which they attributed to the absence of chemicals used for induction of flowering and maturation.

Total phenols

Phenols also called as natural herbicides. Plant secondary metabolites are substances naturally synthesized by the plant. They are typically produced as a plant reaction to various external stimuli acting as regulators of physiological changes in the event of pest / other stresses. In human nutrition, they are important source of antioxidant compounds, so called antioxidants, which protect the body against the influence of many external factors and limit the spread of life style diseases. There are two groups in antioxidants.

1) Nitrogen containing groups.

2) No nitrogen containing groups. Second group includes phenolic acids, flavonoids, terpenoids, carotenoids and xanthophylls. Phenolic acids are the most important group of natural antioxidants due to their great diversity and extensive distribution strongly contributing to the total antioxidant activity. It produced under biotic and abiotic stress.

Głowacka *et al.* (2020) revealed that the total content of polyphenols was significantly higher in organically grown cherry fruits over conventional in four years (2015-18) of experiment presented in Table 1. Plants respond to biotic and abiotic stresses by producing phenolic chemicals, particularly phenolic acids. Phenolic acids are commonly referred to as “natural pesticides”. The greater levels of phenolic acids in plants associated with organic farm management approaches could be due to the absence of pesticides (Xu *et al.*, 2018).

Vitamin A (Carotenoids)

It includes lycopene and beta carotene. Vitamin A is a fat soluble that is naturally present in many foods. It is important for natural vision, immune system and reproduction. It also helps the heart, lungs, kidneys for their natural function.

There are two types in vitamin A. 1) Preformed vitamin A which is present in meat, fish and dairy products 2) Provitamin A also called as β-carotene which is present in fruits and vegetables. It used to protect cells from damage caused by free radical. Then environmental stresses are known to activate the biosynthesis of antioxidants.

Conti *et al.* (2014) made significant differences between organic and conventional strawberry fruit (Table 1). Organic strawberries had higher content of ascorbate and β-carotene compared to conventional fruits. These data are in agreement with previously published research on strawberry (Abu-Zahra *et al.*, 2006; Abu-Zahra and Tahboub, 2009). These results were agreement with the findings of Cardoso *et al.* (2011) reported as vitamin A content was found to be higher in organic strawberries.

Ascorbic acid (vitamin C)

Vitamin C is one of the most important antioxidants found in fruits and vegetables. This vitamin is important for human nutrition and for the food industry as an additive processed food. The main biologically active form of vitamin C is ascorbic acid. During fruit development, ripening is considered as a functionally active form of senescence associated with reactive oxygen species (ROS) accumulation. The antioxidant potential of a produce reflects its ability to deliver bioactive substances that neutralize free radicals produced by oxidative stress.

Cardoso *et al.* (2011) found higher vitamin C content in organic acerola than in conventional fruits presented in Table 1. Vinha *et al.* (2014) observed that organic tomatoes not only were richer in vitamin C (+30%), but also in lycopene (+20%), total phenolics (+24%) and flavonoids (+21%) when compared to conventional ones. These findings corroborate to Oliveira *et al.* (2010) found that passion fruit had higher vitamin C contents (+55%) than conventional passion fruit that were more stressful than in conventional farming. Thus, oxidative stress would have induced the production of reactive oxygen species and in the stimulation of the antioxidant metabolism.

Fruit pH

Fruit pH and water activity are the most influential factors that affect the shelf life and spoilage rate. Variations of pH can influence flavor, consistency and shelf life. fruit juices usually have low pH values that range between 2 and 4.5 due to presence of organic caids that vary within the different types of juices. In order to maintain consistency in the quality monitoring pH is important. Basker, 1992 revealed that there are no significant differences in organic and conventional fruits (Table 1). pH increases significantly during ripening of fruit from both cropping systems. It was due to oxidation of carbon skeletons of organic acids by the respiratory process during ripening.

Fruit pigments

Flavonoids

Flavonoids constitute a large group of thousand different compounds; they play an important role in maintaining health, performing many functions in the human body. It has strong antioxidant and metal chelating activity, influence the neutralization of free radicals. They act as a protector in relation to vitamin C, increasing its effectiveness, supporting the immune system, preventing bacterial and viral infections and have astringent properties. It provides health benefits through cell signaling pathways and antioxidant effect. They are essential pigments for producing the color needed to attract pollinating insects. It also required for UV filtration, Nitrogen fixation and as chemical messenger in plants. The data presented in Table 2 shows, organic sour cherries

Table 1: Effect of conventional and organic farming on nutrient content of fruits.

Fruits	Organic	Conventional
	Minerals	
Calcium (mg)	2.3^{NS}	2.4
Magnesium (mg)	1.6^{NS}	1.6
Potassium (mg)	14.5^{NS}	15
Copper (g)	3.1^{NS}	3.0
Iron (g)	112.0^{NS}	117.9
Zinc (g)	26.3^{NS}	26.1
Chlorides (mg)	1.5^{NS}	1.5
Ammonium	32.3*	49.4
Nitrates (mg)	0.16*	0.22
Phosphates (mg)	1.4^{NS}	1.5
Sulphates (mg)	1.2^{NS}	1.2
	TSS (°Brix)	
Strawberry	8.1^{a}	7.4^{b}
Passion fruit	18.2^{a}	16.5^{b}
	TA (%)	
Strawberry	0.93^{b}	0.99^{a}
Passion fruit	3.99^{b}	4.82^{a}
	Total phenols (mg/100 g FW) in Sour cherry	
2015	5.3^{a1}	3.9^{b}
2016	4.6^{a}	4^{b}
2017	4.3^{a}	3.2^{b}
2018	4.4^{a}	3.0^{b}
	β-carotene (µg/100 g)	
Strawberry	58.7^{*a}	49.3^{b}
Persimmon	703.2^{a}	645.6^{b}
	Ascorbic acid (mg 100 g^{-1})	
Sour cherry	50.5^{a}	41.25^{b}
Passion fruit	19.15^{a}	17.12^{b}
Strawberry	7.1^{*a}	6.2^{b}
	Fruit pH	
Carrot	6.10	6.22^{NS}
Orange	3.39	3.38^{NS}
Banana	4.92	4.77^{NS}
Mango	4.29	4.27^{NS}

[1]Different letters indicate statistically different with each other.
NS- Do not statistically different.
*indicates significant difference at p≤0.05.

contained significantly more total flavonoids (in 2016 and 2018, respectively). The total flavonoid content increased in sour cherry fruits yearly to reach the highest concentration in the last experimental year (2018) reported by Głowacka *et al.* (2020).

Anthocyanin

Anthocyanins are water soluble vacuolar plant pigments that are mainly synthesized in epidermal layers and flesh of fruits such as apples, cherries and other berries. Because of their attractive red to purple coloration and their health promoting potential anthocyanins are significant determinants for the quality and market value of fruits and fruits derived products.

Oliveira *et al.* (2010) reported that, total anthocyanins and yellow flavonoids did not change significantly with ripening of both organic and conventional passion fruit.

In Table 2, Głowacka *et al.* (2020) revealed that among the four seasons of experiment, total flavonoids, including quercetin-3-O-rutinoside, the higher concentration was found in 2015 and 2018. Two individual anthocyanins were identified in sour cherry fruits. Cyanidin-3-O-rutinoside is the predominant form in the pool of total anthocyanins which was high in 2015 and 2018. There were no significant differences was found in all the three years of experiment except 2018 which shows higher concentration of anthocyanin and flavonoids in organic sour cherry over conventional.

Post-harvest performance

Fruit weight

Fruit weight depends on cultivar and temperature rather than on the culture system (organic or conventional). Organic produce having lower level of NPK fertilization result in smaller unit weight.

Oliveira *et al.* (2010) have explained both cropping system and developmental stage influenced quality of passion fruit compared in Table 3. In conventional system (CS), fruit weight increased significantly after the breaker stage, which was not the case for the fruits from the organic system (OS). The cropping system did not significantly influence fruit size nor longitudinal diameter.

Basker, (1992) proved that, for organic and conventional orange, grapes, mango and carrot significant differences were found among the mean unit weights tabulated in Table 3. These differences are ascribed to the longer growing period of the organically grown samples andare thus not relevant to the comparison with conventionally grown ones.

Moisture content and dry weight

Use of organic manures was found to decrease the water content of the fruits which reflected in increasing fruit dry weight. Soft tissues of plants grown under conventional methods collect more water compared with these grown under organic farming. Abu-Zahra, (2008) concluded that, increased level of moisture content in organic fruit can be explained by the “water swelling” phenomenon which is characteristic of conventional fruits. Potassium is an osmoticum which is used to accumulate more moisture in conventional fruits. For the dry matter content results, organic produce gave higher results.

Głowacka *et al.* (2020) differentiated organic and conventional fruits. The organic sour cherry contained significantly more dry matter but only in the first and second experimental years. In 2017, they observed the highest and significant amount of dry matter in conventional fruits; however, in 2018, no differences were noted between farming systems (Table 3).

Crude fiber

Over mature products have higher level of crude fiber. Fiber

Table 2: Effect of organic and conventional farming on fruit pigments.

Fruits	Organic	Conventional
Flavonoids (mg 100 g^{-1})		
Passion fruit	5.25^{a}	4.70^{a}
Sour cherry 2015	68.8^{a}	68.9^{a}
2016	67.3^{a}	58.5^{b}
2017	59.7^{a}	53.0^{a}
2018	77.3^{a}	63.7^{b}
Anthocyanin (mg 100 g^{-1})		
Passion fruit	0.79^{a1}	0.54^{a}
Sour cherry 2015	65.3^{a}	66.5^{a}
2016	63.2^{a}	55.1^{b}
2017	56.4^{a}	49.8^{a}
2018	73.1^{a}	59.6^{b}

Table 3: Post-harvest performance differences in organic and conventional fruits.

Fruits	Organic	Conventional
Weight (g)		
Orange	170^{b}	190^{a}
Grapes	453	343*
Mango	396^{b}	445^{a}
Carrot	66^{b}	109^{a}
Passion fruit	71.58^{b}	79.37^{a}
Moisture content (%)		
Strawberry	92.61	93.37
Dry weight (%)		
Strawberry	7.39	6.63
Sour cherry		
2015	16.0^{a}	14.8^{b}
2016	16.2^{a}	14.3^{b}
2017	13.2^{b}	14.2^{a}
2018	15.0^{a}	14.8^{a}
Crude fibre (%)		
Strawberry	2.96	2.8
Taste (Mean scores)		
Orange	5.7**^{1}	7.2
Grapes	6.4^{a}	7.3^{a}
Bananas	7.7**	6.0
Mango	5.3**	7.2

^{1}**indicates significant difference at p≤0.01.

offers a variety of health benefits and it is essential in reducing risk of chronic disease such as diabetes, obesity and cardiovascular disease.

According to Abu-Zahra, (2008), fruit crude fibre content presented in Table 3 highly differs according to fruit dry weight but it is found to be higher in organically produced fruits in comparison to conventionally produced fruits; the high crude fibre content in the organically produced fruits could ensure better nutritional and health benefits related to fibre consumption.

Taste

There are two ways in which texture has an impact on the flavour of fruits and vegetables. First, the cellular and tissue structure of flesh and the way the structure breaks down during chewing. Second, temporal link between softening and flavour development in fruit.

Basker, (1992) revealed that there were no significant differences in either the nonparametric rating or the 0 to 10 score were found in grapes and significant differences was observed in orange, banana and mango presented in Table 3. Organic fruits like orange, banana and mango fruits having higher taste than conventional fruits. The organic "tastes better" than the conventional type is that lower levels of NPK fertilization result in smaller unit weight, which yields a higher concentration of sugars, total dissolved solids and total dry matter. In turn, this results in better taste.

Quality enhancement of vegetables

Quality parameters at harvest

Nutrient content

Mineral content

Data presented in Table 4 shows (Suja *et al.,* 2017) that biochemical and mineral composition of taro cormels (except K, P and Mg) were not significantly affected due to varieties, production systems. The K, Mg and P contents of conventional cormels were significantly higher than organically produced ones due to the application of inorganic fertilizers. However, inorganically produced cormels had higher P (+3.22%), K (+1.77%) and Mg (+20.80%) contents. Potassium fertilizer can reduce the magnesium content and indirectly the phosphorus content of at least some plants. When potassium is added to soil, the amount of magnesium absorbed by plants decreases. Because phosphorus absorption depends on magnesium, less phosphorus is absorbed as well. Conventional potassium fertilizers dissolve readily in soil water presenting plants with large quantities of potassium while organically managed soils hold moderate quantities of both potassium and magnesium in the root zone of the plant (Bear *et al.*, 1948; Hannaway *et al.*, 1980).

Worthington, 2001 have explained, the organic crops had a higher nutrient content in more than half of the comparisons. For the one toxic compound, nitrates, the organic crop had a lower content the majority of the time. Given the plant responses just described, it would be expected that the organic crops would contain larger

Table 4: Nutrient content of vegetables in organic and conventional faming.

Vegetables	Organic	Conventional
Taro	**Mineral (mg 100 g^{-1} d.w)**	
P	406.6^{a}	393.9^{b}
K	2516^{b}	2593^{a}
Ca	208.5^{NS}	197.6
Mg	68.3^{a}	56.5^{b}
Cu	1.0^{NS}	2.0
Zn	8.48^{NS}	8.39
Mn	20.1^{NS}	21.3
Tomato cultivars	**Total acidity (mg / 100^{-1} g f.w)**	
Amati	0.41	0.48
Robin	0.43	0.47
Elpida	0.49	0.47
	TSS (°Brix)	
Tomato	3.92^{a}	3.86^{a}
	Sugars (%) FW basis	
Taro	1.87^{a}	1.42^{a}
Carrot	6.3^{a}	6.7^{a}
	Phenols (µg of GAE/ g of FW)	
Curry (*Murraya koenigii*)	4357.54	4404.1
Mint (*Mentha spicata*)	1151.08	1096.92
Manathakkali (*Solanum nigrum)*	1051.96	983.53
Agathi (*Sesbania grandiflora*)	1661.65	1382.59
	Total phenols (mg pr 100 g of FW)	
Bell pepper	0.1458^{a}	0.1240^{c}
Tomato	76.7^{a}	68.53^{a}
	β-carotene (µg/100 g)	
Tomato	57^{a}	52^{b}
	Ascorbic acid (mg 100 g^{-1})	
Bell pepper	168.75^{a}	137.25^{c}
Carrot	3.2^{a}	2.9^{b}
Tomato	25.9^{a}	23.6^{b}
	pH	
Bell pepper	4.82^{a}	4.74^{a}
Tomato	4.29^{a}	4.33^{a}
	Crude fibre (%)	
Bell pepper	2.42^{b}	2.18^{b}
	Protein (g/100 g FW)	
Zucchini	0.59^{b}	0.93^{a}
	NO^{-3} (ppm)	
Broccoli	212	271
Cabbage	53	475
Celery	310	230
Lettuce	100	207
Spinach	459	647
	Lycopene (mg 100 g^{-1})	
Bell pepper	0.358^{b}	0.450^{a**}
Tomato	9.31^{a}	9.52^{a}

amounts of magnesium and phosphorus than comparable conventional crops.

Total soluble solids (TSS) and total acidity (TA)

As with the sugars, the organic acids are crucial to the flavour of the fruits. There is a continuous variation in the acidity of the fruit during its development and maturation, increasing with the growth of the fruit until it reaches its maximum with the development of coloration and diminishing with the advance of maturation.

The organic acid in a tomato fruit consists of mainly citric and malic acid with a range of 0.3 to 0.6% (Helyes *et al.*, 2006). Kapoulas *et al.* (2011) showed that conventional tomatoes contained more organic acids in comparison to those cultivated by organic methods, in all periods of analysis, being approximately about 0.48% presented in Table 4. At the same time, it should be noted that 'Elpida' tomatoes were richer in organic acids in comparison to other examined cultivars, independently from the used cultivation system.

Juroszek *et al.* (2009) confirmed that, data calculated across two years showed no significant differences between organic and conventionally produced tomatoes for the fruit quality parameters including, soluble solids [(p) 0.80], acidity [(p) 0.78] and colour [(p) 0.93].

Total sugars

Bender *et al.* (2020) assessed the total sugar content in the carrots, total sugar content did not differ significantly between management systems (Table 4). Suja *et al.* (2017) conducted the experiment on Biochemical and mineral composition of taro cormels were not significantly affected due to varieties, production systems or varieties × production systems interaction. However, organic cormels had higher dry matter (+7.29%), starch (+10.78%), total sugars (+31.55%) and reducing sugars (+9.37%) and conventional cormels had higher phenol, (+6.04%), fibre (+19.78%) and ash (+20.07%).

Total phenols

Mohankumar *et al.* (2018) proved that Green Leafy Vegetables (GLVs) contain an immense variety of bioactive non-nutritive health enhancing factors. GLVs have an abundance of phenolic compounds. Curry leaves (*Murraya koenigii*), a commonly used green in most India preparations had the highest phenolic content ranging from 3468.80± 88.03 to 5084.53±123.49 µg of GAE/g of FW in all the solvents of both OG and CV farming system. Agathi (*Sesbania grandiflora*) and fenugreek *(Trigonella foenum graecum*) had more polyphenolics in water extract. The results presented in Table 4 elucidate that the quantity of total phenolics in GLVs varied among different extracting solvents.

Abu-Zahra, (2011) discussed that organic matter treatments had significantly more total phenols than conventional system in bell pepper. The highest (1458 mg 100 g^{-1}) content was obtained by sheep manure treatment presented in Table 4. It was in agreement with those reported by Leja *et al.* (2008). The lower content of phenolic compounds in the conventional agriculture is due to the increased availability of plant nutrients mainly nitrogen.

One study was conducted by Juroszek *et al.* (2009) revealed that mean values of bioactive compounds with antioxidant activity of fruits showed no significant differences between organic and conventionally produced tomatoes for the fruit nutritional parameters including lycopene [(p) 0.74], ascorbic acid [(p) 0.12], total phenolics [(p) 0.31] andantioxidant activity [(p) 0.64] (Table 4).

Vitamin A

Data in Table 4 shows Juroszek *et al.* (2009) made an experiment on β-Carotene which shows very few significant differences were found between organic and conventionally produced tomatoes in some farm pairs, either in one or both varieties.

Vitamins C

Nitrogen from any kind of fertilizer affects the amounts of vitamin C and nitrates as well as the quantity and quality of protein produced by plants. When a plant is presented with a lot of nitrogen, it increases protein production and reduces carbohydrate production. Bender *et al.* (2020) and Juroszek *et al.* (2009) confirmed that vitamin C content in carrots and tomato varied statistically depending on treatment. Vitamin C content was significantly higher in organic than in conventional as an average across all trial years in Table 4. It was agreement with the findings of Abu-Zahra, (2011) and Worthington, (2001) revealed increased concentration of vitamin C in organic farming over conventional farming.

Vegetable pH

Abu-Zahra, (2011) explained that bell pepper fruit pH does not show any significant differences between all the used treatments presented in Table 4. Fruit pH was ranged from 4.63 ton 4.82 which do not locate within ranges obtained by Rubio *et al.* (2010). Also, our results do not coincide with Llaven *et al.* (2008) who found the addition of sheep manure significantly lowered the fruit pH. Juroszek *et al.* (2009) also explained varietal effects were less pronounced and only significant for pH values of organically produced tomatoes and colour value of conventionally produced tomatoes.

Crude fibre

Abu-Zahra, (2011) made differences between organic and conventional bell pepper crude fibre content. The crude fibre was improved only by the use of cattle manure which produced the highest (2.96%) crude fibre content in Table 4. There are significant differences was observed between all the treatments and the lowest crude fibre content was obtained by conventional treatment.

Proteins

One study was conducted by Maggio *et al.* (2013) in Zucchini and the values tabulated in Table 4. He revealed that increased protein level in conventionally grown crops as a

result of high nitrogen fertilization prohibited in the organic farming. Quantity of protein is less but quality is high in organic farming. The protein content increased with increasing dose of fertilizer when plants were grown conventionally. Although the latter had a negative effect. Slower mineralization rate of nitrogen in inorganic fertilizer used to improve the quality.

Nitrate content in raw vegetables

Nunez *et al.* (2015) assessed the nitrate content in raw vegetables. The mean NO^{-2} concentration of both conventional and organic vegetables ranged between 53-475 ppm of fresh weight (FW) with the exception of conventional spinach that contained 647 ppm FW (Table 4). In most cases, organic vegetables were numerically lower in NO^{-3} content than their conventional counterparts. If there is more N, the excess is accumulated as nitrates and stored in the green leafy part.

Lycopene

The benefits of tomato and tomato products have been attributed mostly to the significant amount of lycopene contained, which constitutes 80-90% of the total carotenoid present in tomato. It has been as a good indicator for fruit maturity stage. The content changed significantly during maturation and accumulated mainly in deep red stage.

Juroszek *et al.* (2009) confirmed that no consistent effect of farming system on the content of bioactive compounds like lycopene in tomato (Table 4). Because pigment production is environment specific. Differences in sunlight and temperature between the years might be a cause for the contradictory observation. It was corroborated with the findings of Abu-Zahra, (2011).

Post-harvest performance

Fresh and dry weight

Maggio *et al.* (2013) confirmed that fresh weight and yield were both significantly higher in plants grown under conventional system and clay soil and they were positively affected by N fertilization and mulching (Table 5).

Dry matter

Bender *et al.* (2020) revealed that carrot dry matter content was not influenced by treatment. The average dry matter content did not differ significantly between organic and conventional system presented in Table 5. It was corroborated with the findings Maggio *et al.* (2013) and Suja *et al.* (2017).

Vegetable size

Conventional treatment resulted in the significantly biggest size 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 size. While in the larger size in sheep manure may be due to the good improvement of soil physical and chemical conditions. And also, conventional farming having higher moisture content leads to increased fruit size.

Data presented in Table 5 shows, Abu-Zahra, (2011) revealed that fruit size ranged from 152.5-172.3 cm^{-3}. The conventional treatment resulted in the significantly biggest fruit size which was due to the good availability of soil nutrients that produced healthy plants with large vegetative growth that reflected in fruit size and smallest fruit was obtained by the poultry manure treatment, which was due to the low availability of soil nutrients and soil physical condition as explained by Abu-Zahara and Tahboub (2009).

Moisture content

Abu-Zahra, (2011) examined fruit moisture content ranged from 90.53-92.05% (Table 5). Use of animal manure was tends to decrease the water content of the fruits which reflected in increasing fruit dry weight but this decrease is only significant with cattle manure which produced the lowest fruit water content in compare to the conventional treatment which produced the highest water content.

Bioavailability of nutrients

Worthington, (2001) was made an attempt to quantify how these differences in nutrient content could affect a person's daily nutrient intake. Estimates of the nutrient content of the vegetable portion a daily menu was made for both an organic and a conventional diet. It was assumed that the five most frequently studied vegetables were consumed: Lettuce, cabbage, spinach, carrot and potato. Organically managed soils generally present plants with lower amounts of nitrogen

Table 5: Effect of organic and conventional farming on post-harvest performance of vegetables.

Vegetables	Organic	Conventional
	Fresh weight (g)	
Chicory	201.3^{b}	261^{a}
Zucchini	134.4^{b}	146.2^{a}
Cauliflower	1179^{b}	1471^{a}
Tomato	101^{b}	124^{a}
	Dry matter %	
Carrot	11.1^{a}	11.2^{a}
Taro	16.4^{a}	15.3^{a}
Chicory	6.6^{a}	6.4^{a}
Zucchini	4.94^{a}	4.83^{a}
Cauliflower	7.6^{a}	7.5^{a}
	Vegetable size (cm^{-3})	
Bell pepper	167.0^{ab}	172.3^{a}
	Moisture content (%)	
Bell pepper	90.53^{ab}	92.05^{a}
	Bioavailability (one day's vegetable intake)	
Vitamin C (mg)	89.2	67.9
Fe (mg)	3.7	3
Mg (mg)	80	68.6
P (mg)	124	111.8
	Taste preference	
Carrot	6.5	6.7^{NS}
Spinach	6.2	6.9^{NS}
Tomato	6.6	6.6^{NS}

than chemically fertilized soils, it would be expected that organic crops would have more vitamin C, less nitrates and less protein but of a higher quality than comparable conventional crops (Table 5).

Taste

Basker, (1992) assessed the taste preference between organic and conventional carrot, spinach and tomato through individual perception using score card. Table 5 shows, no significant differences in either the nonparametric rating or the 0 to 10 score were found for tomatoes, carrots and spinach.

Cooking quality

Polyphenols and flavonoids have shown certain stability when exposed to high temperature. Food processing like cutting of the vegetable tissue and exposure to high temperature, can lead to cellular disruption and disassociation of some phenolic compounds from cellular structures such as lignin and polysaccharides (Bernhart and Schlich, 2005). The soluble polyphenols are most sensitive to cooking than the hydrolysable polyphenols, a behavior evidenced by lower recovery rate and organically grown vegetables suffered more deleterious consequences than conventional vegetables.

Faller and Fialho (2009) conducted the study to quantify soluble and hydrolysable polyphenols, ascorbic acid and the antioxidant capacity of fresh conventional and organic retail vegetables (potato, carrot, onion, broccoli andwhite cabbage) while evaluating the effect of boiling, microwaving and steaming on these parameters presented in Table 6 and 7. The recovery rate for soluble and hydrolysable polyphenols was variable according to the vegetable analysed. However, soluble polyphenols resulted in lower recovery rates than did hydrolysable phenolics after cooking.

Contaminant level between organic and conventional crops

Microbial toxins

Organic produce is more exposed to microbiological contamination than conventional produce, since organic fertilizers often consist of manure and manure may harbour pathogenic microorganism such as *Salmonella spp etc.* out of all organic foods, vegetables stand out as important source of foodborne illness.

Merlini *et al.* (2018) examined the comparative microbial analysis between two farming system. *Salmonella spp.,* did not find any of the samples. Table 8 indicates increased microbial count was observed in organic vegetables compared with conventional vegetables. He concluded that both farming system produces contains some amount of microorganism. But organic varieties have greater counts over conventional.

Table 6: Soluble polyphenols in organic and conventional vegetables.

Soluble polyphenols	Type of agriculture	Raw vegetables (mg GAE/ ml VE)	% Recovery		
			Boiled	Microwaved	Steamed
Carrot	Organic	0.52^{a}	40.9^{b}	43.5^{b}	52.1^{b}
	Conventional	0.28^{ab}	110.7^{a}	150.3^{a}	44.3^{b}
Onion	Organic	0.195^{a}	380^{b}	273.6^{c}	249.2^{c}
	Conventional	0.32^{a}	195.2^{b}	140.1^{a}	124.8^{a}
Potato	Organic	0.39^{a}	74.2^{a}	110^{a}	87^{a}
	Conventional	0.32^{a}	263.7^{b}	205.9^{b}	64.9^{a}
Broccoli	Organic	1.23^{a}	76^{b}	71.1^{b}	63^{b}
	Conventional	1.17^{a}	73.9^{a}	109.1^{a}	95.6^{a}
White cabbage	Organic	0.64^{a}	86.3^{a}	61.5^{a}	36.1^{a}
	Conventional	0.52^{ab}	104.5^{a}	59.4^{b}	50.2^{b}

Table 7: Hydrolysable polyphenols in organic and conventional vegetables.

Hydrolysable polyphenols	Type of agriculture	Raw vegetables (mg GAE/ mL VE)	% Recovery		
			Boiled	Microwaved	Steamed
Carrot	Organic	0.80^{a}	77.6^{a}	87.3^{a}	80.2^{a}
	Conventional	0.62^{a}	112.7^{a}	108.9^{a}	123.3^{a}
Onion	Organic	1.20^{a}	74.6^{b}	114.9^{c}	105.4^{ac}
	Conventional	0.93^{a}	156^{b}	155.3^{b}	163.2^{b}
Potato	Organic	0.35^{a}	181.4^{a}	180.8^{a}	122.8^{a}
	Conventional	0.42^{a}	355.9^{b}	274.3^{ab}	85.6^{a}
Broccoli	Organic	2.31^{a}	53.2^{b}	55.6^{b}	46.9^{b}
	Conventional	2.01^{ac}	65^{b}	81.4^{bc}	125.7^{a}
White cabbage	Organic	1.69^{a}	39.7^{b}	56.3^{b}	37.5^{b}
	Conventional	1.36^{a}	34.9^{b}	55.2^{b}	100.6^{a}

Heavy metals concentration (mg/kg)

Agricultural activities such as inorganic fertilizers, pesticides and manure application as well as sewage irrigation are known source of contaminant. Fertilizers and pesticides contain various levels of heavy metals such as cadmium and copper. These substances are very persistent and heavy application of agrochemicals and soil amendments increase the accumulation of heavy metals in agricultural soil over time.

Data presented in Table 9 indicates Glodowska and Krawczyk (2017) confirmed that significantly increased concentration of Cd, Co was detected in conventional over organic farming. Using atomic absorption spectroscopy, the plant samples were analysed and tested for concentration of heavy metals (Cd, Co, Cr, Cu, Fe, Mn, Ni, Pb and Zn). A chemical analysis of collected samples showed that there are significant differences between vegetables cultivated in the two growing systems. Generally, 64% conventionally grown vegetables showed increased level of heavy metals. It was also found that celery and parsley leaves have a tendency to assimilate more heavy metals compared to other vegetables. The main reason is due to fertilizer application, physiochemical differences of the soil, localization of farm and differences in bio assimilation of some elements by plants.

Pesticides

Pesticides are chemicals used in agriculture to protect crops against insect, fungi, weed and other pest. Pesticides are potentially toxic to humans. They induce adverse health effects including cancer, effect on reproduction, immune or nervous system. There are two effects due to pesticide residues. 1) Acute effects which leads to abdominal pain, dizziness, headaches, vomiting, skin and eye problems. 2) long term effects which leads to cancer, neurological, reproductive effects, dermatitis and diabetes.

Data in Table 10 shows Tobin *et al.* (2014) proved that analysis for 465 pesticide residues was carried out using GC-MS/MS and LC-MS/MS analysis. Of the 27 organic samples tested, 15 contained one or more detected pesticide residues, with one of these being above the limit of quantification (LOQ) for the method, imazalil in organic onion, 11.13 ng/g. Of the conventional samples 17 of the 27 samples contained one or more residues. Twelve of the

Table 8: Microbial toxins in organically and conventionally grown vegetables.

Vegetables	Mesophilic aerobic bacteria		Yeasts and moulds		Total coliforms		*Escherichia coli*	
	CC	OC	CC	OC	CC	OC	CC	OC
Lettuce	6.66	6.69	6.61	6.31	4.04	3.18	1.23	1.16
Chicory	6.57*	7.19*	6.03	6.10	4.28	4.64	1.49	1.45
Catalogna	7.48	6.67	6.01	6.02	5.05	4.69	1.50	1.49
Collard greens	6.24	6.33	5.48	5.43	2.94*	4.22*	1.48	<1.00
Arugula	6.25	6.85	5.09*	6.36*	2.93	2.99	1.30	2.09

[1]OC- Organic cultivation.

CC- Conventional cultivation.

Table 9: Heavy metals concentration (mg/kg) in organically and conventionally grown vegetables.

	Type of farming	Cd	Co	Cr	Cu	Fe	Mn	Ni	Pb	Zn
Parsley (root)	Organic	0.09[b]	0.06	1.38	3.85[b]	29.8	18.1	4.02	2.26	42.3
	Conventional	0.14[a]	0.09	1.71	7.18[a]	33.5	18.1	4.17	1.44	16.6
Beet	Organic	0.04	0.02[b]	1.28	3.34[b]	22.7[b]	25.1	4.35	1.12	23.0[a]
	Conventional	0.09	0.09[a]	2.17	4.15[b]	34.3[a]	24.8	4.25	1.70	15.5[b]
Parsley (leaves)	Organic	0.12	0.10	1.96	7.43	26.8	45.1	4.60	2.14	72.1[a]
	Conventional	0.09	0.218	5.54	11.9	106	56.8	6.41	2.20	46.1[b]
Leek	Organic	0.09	0.13	1.40	3.59	31.6	17.1[b]	4.17	1.51	30.1
	Conventional	0.16	0.14	1.93	4.50	33.5	21.8[a]	4.29	2.05	27.4
Celery	Organic	0.52	0.094	1.50	12.4	41.2[b]	29.5[b]	4.72	2.07	41.1
	Conventional	1.08	0.106	2.02	11.9	72.4[a]	62.8[a]	5.01	2.43	37.5
Carrot	Organic	0.17	0.089	1.97	3.74	11.2	13.1	5.89	0.935	24.9[a]
	Conventional	0.24	0.016	1.23	4.46	6.86	14.8	4.17	2.35	13.8[b]
Potato	Organic	0.05	0.8	0.88	5.39[a]	17.9	12.1	3.87[b]	2.99	18.3
	Conventional	0.07	0.07	0.72	2.46[b]	23.8	23.8	4.14[a]	2.30	12.7
Onion	Organic	0.16[b]	0.052[b]	1.26[a]	4.09	13.2	15.8[b]	4.91	2.94	25.1[a]
	Conventional	0.21[a]	0.087[a]	0.39[b]	2.94	7.80	18.8[a]	4.21	0.95	12.3[b]

[1]OC- Organic cultivation.

CC- Conventional cultivation.

Table 10: Pesticide residues in organic and conventional farming.

	Organic (n=27)	Conventional (n=27)
No. of samples containing detectable residues	15	17
No. of total residues (>LOQ)	1	13
Concentration range of residues quantified	11.13 ng/g	9.84-154.07 ng/g

residues detected in conventional samples were above the LOQ with concentrations ranging from 9.84 to 154.10 ng/g. A similar number of organic (15) and conventional (17) samples tested positive for detectable residues, however the number of residues detected was higher in conventional (43) than in organic (29) andthe concentration of these residues were higher. It is concluded that it cannot be said that organic fruits and vegetables are void of pesticides based on the results of this study. It was agreement with the findings of Oliveira *et al.* (2010).

CONCLUSION

Among different parameters analyzed, parameters like vitamins, total phenols, dry matter, fiber, TSS were higher in organic fruits and vegetables than conventional products. Other mineral nutrient contents like Ca, Mg, Zn, Fe, Cu, Mn, P are similar to conventional and organic farm produce. Heavy metals contamination, ammonium and nitrate contents were lower in organic than conventional fruits and vegetables. Cooking of organic vegetables at high temperatures is not preferable dur to their higher sensitivity to high temperature and loss of polyphenols. The quality and yield of farming system was dependent on inputs, crop, variety, location, soil and climate. Organic foods are better for the environment andmore nutritious. It can be concluded that organic crops have a lower number of contaminants, but a higher quality compared to conventional crops.

Conflict of interest

All the authors declared that there was no conflict of interest

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