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COMPARATIVE ANALYSIS OF NUTRITIONAL, ANTIOXIDANT AND PHYTOCHEMICAL PROPERTIES OF ORGANIC VS. INORGANIC TOMATOES

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ABSTRACT

This study compares the quality and health benefits of organic and inorganic tomatoes through sensory, nutritional, antioxidant, mineral, phytochemical, and pesticide residue analyses. Organic tomatoes revealed superior sensory attributes, including better appearance, texture, flavor, and aroma, alongside higher levels of essential nutrients, minerals, and antioxidants compared to inorganic tomatoes. Specifically, organic tomatoes exhibited increased antioxidant activity, total phenolic content, lycopene, and vitamin C levels. Mineral analysis revealed higher concentrations of potassium, calcium, and magnesium in organic tomatoes. Phytochemical profiles were similar between both types, though both showed high saponin content. Notably, organic tomatoes had no detectable pesticide residues, while inorganic tomatoes had trace amounts of several pesticides. These findings suggest that organic tomatoes not only offer enhanced sensory and nutritional benefits but also pose a lower risk of pesticide exposure, supporting the continued adoption of organic farming practices for improved food safety and nutrition

Keywords: Antioxidant Activity, Nutrient Analysis, Mineral Analysis, Total Phenolic Content, Vitamin C Content, Organic Fruit, Inorganic Fruit

INTRODUCTION

Tomatoes (*Solanum lycopersicum*) are among the most commercially significant vegetables cultivated globally. As a member of the Solanaceae family, which encompasses over 3,000 species including potatoes, tobacco, peppers, and eggplants, tomatoes stand out due to their extensive use and nutritional value. They are

the sole domesticated species in the section Lycopersicon of the genus Solanum, which includes 13 species or subspecies. This widespread cultivation underscores the tomato's crucial role in the global food supply.

Tomatoes are rich in a variety of essential nutrients, providing vitamins, minerals, fiber, protein, essential amino acids, monounsaturated fatty acids, carotenoids, and phytosterols. These nutrients contribute to various physiological functions and health benefits. For instance, the dietary fiber in tomatoes aids in constipation prevention, while the vitamins and minerals help maintain overall bodily functions and support metabolic processes. The monounsaturated fatty acids and carotenoids, including the prominent lycopene, offer additional health benefits, such as supporting cardiovascular health and providing antioxidant protection.

The primary carotenoid in tomatoes is lycopene, which imparts the characteristic red color to the fruit. Lycopene is renowned for its potent antioxidant properties and has been linked to various pharmacological activities, including anticancer, anti-inflammatory, antidiabetic, anti-allergenic, anti-atherogenic, antithrombotic, antimicrobial, and vasodilatory effects. These attributes make lycopene a significant focus in nutritional and health research related to tomatoes.

The method of farming can significantly impact the quality of tomatoes. Organic farming typically involves the use of natural fertilizers and pest control methods, which often results in reduced pesticide residues and lower levels of soil contamination. In contrast, conventional (inorganic) farming frequently relies on synthetic fertilizers and pesticides. Recent studies highlight concerns about pesticide residues in conventionally grown fruits and vegetables, which may exceed safety limits and pose potential health risks. In organic farming, the total pesticide content in soils is substantially lower, ranging from 70–90% less compared to conventional methods.

The quality of tomatoes is influenced by their cultivation practices. Organic farming is associated with the production of high-quality fruit with enhanced nutritional attributes. The reduced pesticide residue in organic tomatoes is a notable advantage, contributing to their perceived health benefits. Furthermore, organic farming practices often emphasize soil health and sustainable agriculture, which can further enhance the nutritional profile of the produce. This study aims to investigate and compare the nutritional, antioxidant, mineral, and phytochemical properties of tomatoes grown using organic and inorganic farming methods.

MATERIALS AND METHODS

Sample Collection

Tomatoes used in this study were procured from local farms practicing organic and inorganic farming methods. Organic tomatoes were obtained from certified organic farms, while inorganic tomatoes (*Pusa Ruby*) were sourced from conventional farms using synthetic fertilizers and pesticides. Each sample consisted of approximately 3 kg of ripe tomatoes, collected during the peak growing season to ensure consistency in ripeness and quality.

Fig 1. Organic tomatoes

Fig 2. Inorganic tomatoes

Sensory Analysis of organic and inorganic tomato varieties

Sensory analysis of organic and inorganic tomato varieties was conducted using a 7-point hedonic scale to evaluate attributes such as flavor, texture, aroma, and overall acceptability. Fresh, ripe tomatoes from both farming methods were prepared by washing and slicing them into uniform pieces. A panel of trained testers, consisting of 20 individuals, was recruited to assess the samples in a controlled environment. Each participant evaluated the tomatoes for various sensory attributes on a 7-point scale, where 1 represented "dislike extremely" and 7 represented "like extremely." Sensory data were collected and analyzed statistically to compare the overall acceptability and specific attributes of the organic and inorganic tomato samples.

Nutritive Analysis of organic and inorganic tomato varieties

Nutrient analysis of carbohydrates, proteins, fats, fiber, ash, and moisture content in organic and inorganic tomato varieties was conducted using standard analytical methods. Carbohydrates were determined using the differential method, which involves hydrolyzing the sample with acid followed by enzymatic digestion and measurement of reducing sugars using the phenol-sulfuric acid method (Dubois et al., 1956). Proteins were quantified using the Kjeldahl method, which includes digestion, distillation, and titration to measure nitrogen content, converted to protein percentage (AOAC, 2016). Fats were analyzed through Soxhlet extraction with petroleum ether, followed by evaporation of the solvent to determine the fat content (AOAC, 2016). Dietary fiber was measured using the enzymatic-gravimetric method, involving enzyme digestion to separate soluble and insoluble fiber components (Prosky et al., 1992). Ash content was determined by incinerating the sample at 550°C until a constant weight was achieved (AOAC, 2016). Moisture content was assessed by drying the sample at 105°C until a constant weight was obtained (AOAC, 2016).

Antioxidant properties organic and inorganic tomato varieties

The antioxidant capacity of in organic and inorganic tomato varieties was assessed by using assays:

DPPH Radical Scavenging Assay

The 2,2-diphenyl-1-picrylhydrazyl (DPPH) radical scavenging activity was measured as described by Brand-Williams et al. (1995). The percentage inhibition was calculated to evaluate the antioxidant potential.

ABTS Radical Cation Decolorization Assay

The 2,2'-azinobis (3-ethylbenzothiazoline-6-sulfonic acid) (ABTS) assay was performed according to Re et al. (1999) to determine the antioxidant capacity by measuring the reduction of ABTS radicals.

Total phenolic content was measured using the Folin-Ciocalteu method. Tomato samples were homogenized and extracted with methanol. The extract was mixed with Folin-Ciocalteu reagent and sodium carbonate solution, incubated for 90 minutes, and the absorbance was read at 765 nm using a spectrophotometer. Results were expressed as milligrams of gallic acid equivalents per gram of sample (Singleton et al., 1999).

Lycopene content was determined by High-Performance Liquid Chromatography (HPLC). Tomato extracts were prepared with acetone, and the resulting solution was filtered and injected into an HPLC system equipped with a C18 column and detected at 472 nm. Lycopene content was quantified against a standard curve of pure lycopene and reported as micrograms per gram of sample (Markovic et al., 2008).

Vitamin C levels were assessed using the 2,6-dichlorophenolindophenol (DCPIP) titration method. Tomato juice was prepared, titrated with DCPIP solution until a persistent color change was observed, and vitamin C concentration was calculated based on the volume of DCPIP used (Roe & Kuether, 1943).

Mineral Analysis of tomato samples (organic and inorganic)

Mineral analysis of potassium, calcium, and magnesium in tomato samples was performed following AOAC methods. The procedure involved first drying and grinding the tomato samples to a fine powder. A 0.5 g portion of the powdered sample was digested using concentrated nitric acid and hydrochloric acid in a microwave digestion system, according to AOAC guidelines (AOAC, 2016). The digested solution was then diluted with deionized water and analyzed by Atomic Absorption Spectroscopy (AAS) for potassium, calcium, and magnesium. Calibration standards for each mineral were prepared and used to create calibration curves for quantification.

Phytochemical analysis of Organic and Inorganic Tomatoes

Phytochemical analysis of organic and inorganic tomatoes for alkaloids, flavonoids, saponins, tannins, and phytates, follow these steps: Collect ripe tomato samples and divide them into organic and inorganic groups. Dry the samples at 40°C until constant weight is achieved, then grind them into a fine powder. For alkaloid determination, perform a solvent extraction with 10% acetic acid in ethanol, followed by precipitation with Dragendorff's reagent. Flavonoids are quantified using the aluminum chloride method, where the extract is treated with aluminum chloride and absorbance is measured at 415 nm. Saponins are analyzed using the foam test, where the extract is shaken with water and observed for foam stability. Tannins are assessed through the use of a standard $FeCl_3$ test, where the extract is mixed with FeCl3 solution and observed for color change. Phytates are measured using the Wade's reagent method, involving the extraction of phytates and their reaction with Wade's reagent to form a colored complex, which is then quantified spectrophotometrically at 500 nm (Harborne (1998)).

Pesticidal Residue Detection in tomato samples (organic and inorganic)

Pesticide residue detection in tomato samples for organic and in organic varieties for 2,4-Dichlorophenyl-dichloroethane (2,4-DDT), 4,4'-Dichlorodiphenyltrichloroethane (4,4-DDT), Chlorpyrifos, 2,4-Dichlorophenoxyacetic acid (2,4-D), Methyl Parathion, and Butachlor was conducted using Gas Chromatography-Mass Spectrometry (GC-MS). Tomato samples were first homogenized and then subjected to

a solid-phase extraction (SPE) using an appropriate cartridge to isolate the pesticides from the sample matrix (Moffat et al., 1986).

RESULTS AND DISCUSSION

Sensory Analysis of Organic and Inorganic Tomatoes

Sensory analysis revealed significant differences between organic and inorganic tomatoes across various attributes (Table 1).

Table 1: Comparison of Scores for organic and inorganic tomatoes.

Attributes	Organic Tomatoes	Inorganic Tomatoes
Appearance	6.2 ± 0.74	5.05 ± 0.76
Texture	6.6 ± 0.49	5.6 ± 0.57
Flavor	6.05 ± 0.80	4.7 ± 0.48
Aroma	5.1 ± 0.85	4.1 ± 0.77
Overall acceptability	5.99 ± 0.63	4.86 ± 0.60

Organic tomatoes consistently received higher scores than inorganic tomatoes for appearance (6.2 vs. 5.05), texture (6.6 vs. 5.6), flavor (6.05 vs. 4.7), aroma (5.1 vs. 4.1), and overall acceptability (5.99 vs. 4.86). Statistical analysis using independent t-tests showed significant differences in appearance ($p < 0.01$), texture ($p < 0.01$), flavor ($p < 0.01$), and overall acceptability ($p < 0.05$), indicating that organic tomatoes were perceived more favorably by panelists. The higher scores for organic tomatoes may be attributed to the absence of synthetic chemicals and the potential benefits of organic farming practices, which could enhance the sensory qualities of tomatoes. In contrast, inorganic tomatoes scored lower in all attributes, which may reflect the impact of synthetic inputs on flavor and texture, as well as potential pesticide residues affecting aroma.

Nutritive Analysis of Organic and Inorganic Tomatoes

The nutritive analysis presented in Table 2 demonstrates that organic tomatoes generally exhibit higher nutrient levels compared to inorganic tomatoes. Organic tomatoes showed higher carbohydrate (3.22 g/100g vs. 3.10 g/100g), protein (1.25 g/100g vs. 0.84 g/100g), and fat content (0.50 g/100g vs. 0.21 g/100g) than their inorganic counterparts. Although fiber content was slightly higher in organic tomatoes (1.30 g/100g) compared to inorganic tomatoes (1.25 g/100g), the difference was minimal. Organic tomatoes also had a higher ash content (1.48 g/100g vs. 1.25 g/100g), which may indicate a greater mineral concentration. Conversely, inorganic tomatoes had a slightly higher moisture content (93.35 g/100g vs. 92.25 g/100g), potentially due to differences in agricultural practices affecting water retention.

Table 2: Nutritive Analysis of Organic and Inorganic Tomatoes

Components	Organic tomato's	Inorganic tomato's	Units
Carbohydrates	3.22	3.10	g/ 100g
Proteins	1.25	0.84	g/ 100g
Fat	0.5	0.21	g/ 100g
Fiber	1.30	1.25	g/ 100g
Ash	1.48	1.25	g/ 100g
Moisture	92.25	93.35	g/ 100g

These results suggest that organic tomatoes may offer enhanced nutritional benefits, particularly in protein and fat content, which could be attributed to the natural farming practices that avoid synthetic fertilizers and pesticides. The higher carbohydrate and ash content in organic tomatoes also aligns with the expected nutrient density from organic cultivation. However, the minimal differences in fiber and moisture content indicate that while organic tomatoes may provide some nutritional advantages, the overall impact on fiber and moisture is relatively modest. These results suggest that organic farming practices may enhance the nutrient profile of tomatoes. However, additional research is needed to fully understand the broader effects on nutritional quality and health benefits.

Mineral Analysis of Organic and Inorganic Tomatoes

The mineral analysis presented in Table 3 indicates that organic tomatoes generally contain higher levels of potassium, calcium, and magnesium compared to inorganic tomatoes. Specifically, organic tomatoes had 260.8 mg/100g of potassium, 10.20 mg/100g of calcium, and 13.55 mg/100g of magnesium, while inorganic tomatoes had 247.5 mg/100g of potassium, 8.35 mg/100g of calcium, and 10.63 mg/100g of magnesium. These differences suggest that organic tomatoes may provide superior mineral content, which could be attributed to the use of organic soil amendments and cultivation practices that enhance soil health and nutrient availability.

Table 3: Mineral Analysis of Organic and Inorganic Tomatoes

Mineral	organic tomato's	In organic tomato's	Units
Potassium	260.8	247.5	mg/100g
Calcium	10.20	8.35	mg/100g
Magnesium	13.55	1.0.63	mg/100g

The higher concentrations of potassium, calcium, and magnesium in organic tomatoes could contribute to their potential health benefits, such as improved cardiovascular health and bone strength. The higher mineral content in organic tomatoes highlights the potential benefits of organic farming in improving the nutritional value of product.

Antioxidant activity of Organic and Inorganic Tomatoes

Organic tomatoes demonstrated significantly higher antioxidant activity compared to inorganic tomatoes (Table 4). The DPPH assay showed an antioxidant value of 264.50 ppm for organic tomatoes, markedly higher than 156.50 ppm for inorganic tomatoes, indicating superior free radical scavenging ability. The ABTS assay further confirmed this, with organic tomatoes displaying an antioxidant capacity of 4.87 GAE/g versus 2.44 GAE/g in inorganic tomatoes. Additionally, organic tomatoes had a greater total phenolic content (122.30 mg GAE/100 g) compared to inorganic tomatoes (90.76 mg GAE/100 g). They also contained more lycopene (3.42 mg/100 g vs. 2.25 mg/100 g) and vitamin C (17.60 mg/100 g vs. 11.45 mg/100 g), reflecting their enhanced antioxidant potential.

These findings suggest that organic tomatoes offer superior antioxidant benefits, likely due to their higher concentrations of phenolic compounds, lycopene, and vitamin C. The increased antioxidant activity in organic tomatoes highlights the potential health advantages of organic farming practices.

Table 4: Antioxidant activity of Organic and Inorganic Tomatoes

Antioxidant activity	Organic tomato's	In Organic tomato's	Units
DPPH Assay	264.50	156.50	ppm
ABTS Assay	4.87	2.44	GAE/g
Total Phenolic Content	122.30	90.76	mg GAE/ 100 g
Lycopene Content	3.42	2.25	mg/100 g
vitamin C Content	17.60	11.45	Mg/ 100 g

The Phytochemical Analysis of Organic and Inorganic Tomatoes

Phytochemical The phytochemical analysis of organic and inorganic tomatoes, as detailed in the Table 5. The phytochemical analysis of organic and inorganic tomatoes reveals the presence of alkaloids, flavonoids, saponins, tannins, and phytates in both types of tomatoes, with varying levels of abundance. Both organic and inorganic tomatoes showed similar levels of alkaloids, flavonoids, and tannins (+). However, saponins were found in high abundance (+++) in both organic and inorganic tomatoes, indicating a significant concentration of these compounds in the samples. Phytates were present in moderate abundance (+) in both types, suggesting a relatively consistent presence across the tomato varieties. These findings suggest that the phytochemical profiles of organic and inorganic tomatoes are comparable, though both types exhibit high levels of saponins, which could imply a common factor influencing saponin concentration in tomato cultivation.

Table 5: The Phytochemical Analysis of Organic and Inorganic Tomatoes

Components	organic	In-organic
Alkaloids	+	+
Flavonoids	+	+
Saponins	+++	+++
Tannins	+	+
Phytates	+	+

Note: high abundance +++, moderate abundance ++, abundance +

Pesticidal Residue in Organic and Inorganic Tomatoes

The examination of pesticidal residues in organic versus inorganic tomatoes revealed a distinct difference between the two types. Organic tomatoes showed no detectable residues of 2,4-DDT, 4,4-DDT, chlorpyrifos, 2,4-D, methyl parathion, or butachlor, which aligns with the stringent standards set for organic produce. In

contrast, inorganic tomatoes contained detectable levels of these pesticides, though at very low concentrations (<0.0001 µg/l). These results highlight the efficacy of organic farming methods in eliminating synthetic pesticide residues, in accordance with organic farming principles. Although the pesticide levels in inorganic tomatoes fall within regulatory thresholds, they still present a higher risk of exposure compared to organic tomatoes.

Table 6: Pesticidal Residue in Organic and Inorganic Tomatoes

Test parameter	organic	inorganic	units
2,4-DDT	Not Found	<0.0001	µg/1
4,4-DDT	Not Found	<0.0001	µg/1
Chlorpyrifos	Not Found	<0.0001	µg/1
2,4-D	Not Found	<0.0001	µg/1
Methyl parathion	Not Found	<0.0001	µg/1
Butachlor	Not Found	<0.0001	µg/1

Overall, the analysis indicates that while the inorganic sample contains trace amounts of several pesticide residues, the organic sample demonstrates a cleaner profile with no detectable pesticide residues, highlighting the potential benefits of choosing organic produce for consumers concerned about pesticide exposure.

CONCLUSION

This study highlights the significant advantages of organic tomatoes compared to inorganic. Organic tomatoes exhibited superior sensory qualities, such as improved appearance, texture, flavor, and aroma, and were also higher in essential nutrients, minerals, and antioxidants. The absence of detectable pesticide residues in organic tomatoes highlights the benefits of organic farming in minimizing chemical exposure. Although some nutritional differences were minor, the overall higher quality and health benefits of organic tomatoes suggest they are a better choice for consumers concerned about pesticide residues and seeking enhanced nutritional value. These results support for the continued use of organic farming practices to ensure safer and more nutritious produce.

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