

Functional and Morphological Studies of Organic and Inorganic Tomatoes

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History

- Submission Date: 17-01-2018;
- Revised Date: 06-03-2018
- Accepted Date: 03-05-2018

DOI : 10.5530/pj.2018.4.119

Article Available online

<http://www.phcogj.com/v10/i4>

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ABSTRACT

Aim: To study the functional and morphological characteristics of organic and inorganic tomatoes. **Methodology:** UV treated, and untreated organic and inorganic tomato powdered samples were assessed using an analytical technique FT-IR and SEM. **Results:** FT-IR spectra of organic control samples showed peaks at (3290.12, 2924.72 and 1611.61 cm^{-1}) while, organic treated samples revealed some peaks at (3287.11, 2925.66 and 1612.91 cm^{-1}), inorganic control tomatoes confirmed the peaks at (3289.47, 2925.76 and 1619.26 cm^{-1}) and in inorganic treated tomatoes peaks was at (3289.42, 2925.34 and 1619.31 cm^{-1}) respectively, on confirming the presence of O-H, C-H, C=C, C=O and C-OH functional groups. However, results confirmed slight changes in functional groups of organic and inorganic samples and UV treatment helps in decreasing the effect of fluoride, chloride and other synthetic chemicals level by disinfecting the samples. SEM micrographs showed non-significant changes with minimal effect of UV in all samples. **Conclusion:** The outcome of the study helps in effective understanding of functional and microstructural differences between organic and inorganic tomatoes.

Key words: Organic, Inorganic, Tomatoes, UV treatment, FT-IR, SEM.

INTRODUCTION

Tomato is an important source of micronutrients, minerals like potassium and carboxylic acids, including ascorbic, citric, malic, fumaric and oxalic acids.^{1,2} Recent epidemiological studies have suggested that the consumption of tomatoes and tomato-based food products helps in reducing the risk of cardiovascular disease and cancer (oral cavity, pharynx, esophagus, stomach, rectum, colon, urinary bladder, prostate and breast) in humans as reported by,^{3,4,5} and this protective effect has been attributed to carotenoids, in particular lycopene and phenolic compounds which are considered as one of the major classes of phytochemicals in this fruit.⁶ As we know carotenoids are a family of compounds of over 600 fat-soluble plant pigments that provide much of the color we see in nature, by facilitating important nutritional benefits to human population owing to their pro vitamin A and antioxidant activities.⁷

Increasing demand and interest towards organically grown fruits and vegetables and its products imposed the need to study the quality and nutritional differences between organic and inorganic tomatoes. Some studies have shown higher number of bioactive compounds in organically produced tomatoes compared to conventional,^{8,9,10} and are often linked in protecting the environment and having better quality in terms of taste with enhanced storage period.

Ultra Violet (UV) radiation is a surface sterilization treatment for increasing shelf life of fruits and vegetables that are highly susceptible to microbial spoilage. UV radiation is a promising non-thermal preservation method classified into UV-A (315-400 nm), UV-B (280-315 nm) and UV-C (200-280 nm) respectively. UV-C has the germicidal effect since it inactivates the microorganisms.¹¹ Fresh fruits and vegetables exposed to low doses of UV induces anti-fungal compounds and delays ripening there by enhancing shelf-life.

Functional groups are specific group of atoms or bonds present within the molecules which are responsible for the characteristic chemical reactions of those molecules. The fresh and processed tomatoes contain volatile compounds falls under various chemical classes like ketones, aldehydes, alcohols, esters, ethers, hydro- carbons, sulfur, nitrogen and oxygen compounds, phenols, oxygen-containing heterocyclic compounds, free acids and lactones.¹² FTIR is a powerful technique that can be used to obtain an infrared spectrum of absorption or emission of all states of matter (solid, liquid and gas). The morphological study becomes important in knowing the form and structure of any food material that can be achieved with the help of SEM. The present study focusses on analyzing and comparing

Cite this article: Shwetha MS, Sinija VR, Durgadevi M, BK Yadav, Shanmugasundaram S. Functional and Morphological Studies of Organic and Inorganic Tomatoes. Pharmacogn J. 2018;10(4):715-9.

the functional group and morphological differences between organic and inorganic tomatoes before and after UV treatment by using FTIR and SEM.

MATERIALS AND METHODS

Sample collection

Freshly harvested riped organic and inorganic tomatoes (Variety: Sivam) were procured from Coimbatore and Thanjavur, Tamil Nadu, India. Every effort was made in maintaining the quality of samples throughout the supply chain.

Preparation of sample

UV treatment and tray drying

A laboratory model of continuous UV-C system was used for the experiment consisting of conveying system, treatment chamber, control system and holding frame. Fresh tomato samples were subjected to UV treatment for 10-15 min (8×15W). Treated and untreated organic and inorganic tomato samples were sliced to 6-8 mm thickness and subjected to tray drying at 50°C for 14-16 hrs. Further, the dried slices were processed into fine powder by using a blender and passed through different sieves to achieve uniform particle size.

Bio-chemical analysis

Organic and inorganic tomatoes were analyzed for bio-chemical properties like pH (pH meter), TSS (Refractometer), titratable acidity, vitamin C and lycopene by standard protocols.^{13,14}

Functional group analysis

Fourier transform infrared spectrophotometer is an important tool for identifying the presence of different types of chemical bonds (functional groups) present in compounds. Dried powders of different sample specimen were loaded in FTIR Spectroscope by taking a small quantity to know the presence of functional groups in tomatoes (Shimadzu, IR Affinity1, Japan), with a scan range from 400 to 4000 cm^{-1} with a resolution of 4 cm^{-1} respectively.

Morphological analysis

The microstructure of the tray dried organic and inorganic (control and treated) tomato samples were investigated using a normal scanning electron microscope (SEM, VEGA3 TESCAN).

RESULTS AND DISCUSSIONS

Bio-chemical analysis

Quality attributes of fresh organic and inorganic tomatoes are presented in Table 1. Organic samples showed better results on confirming TSS (4.7 °Brix), vitamin C (22.5 mg/100g), lycopene (4.13 mg/100g), with reduced acidity (0.38%), pH was (4.2) indicating samples were more acidic. Whereas, inorganic tomatoes exhibited decreased amount of TSS, vitamin C and lycopene (4.1 °Brix, 20.2 mg/100g, 3.35 mg/100g), with increasing in acidity (0.43%).

Table 2: FTIR spectra (cm^{-1}) for UV treated and untreated organic and inorganic tomatoes.

Sl. No	Functional group	Organic samples		Inorganic samples	
		Control	Treated	Control	Treated
1	O-H stretch	3290.12	3287.11	3289.47	3289.42
2	C-H stretch	2924.72	2925.66	2925.76	2925.34
3	C=C and C=O	1611.61	1612.91	1619.26	1619.31
4	C=C	1403.6	1402.74	1407.24	1406.29
5	C-F	-	-	1315.15	1244.06
6	C-OH stretch	1039.34	1041.36	1036.08	1035.35

Table1: Bio-chemical composition of organic and inorganic tomatoes.

Sl. No	Component	Organic tomatoes	Inorganic tomatoes
1	pH	4.2±0.05	4.5±0.05
2	TSS (°Brix)	4.7±0.05	4.1±0.00
3	Titratable acidity (%)	0.38±0.01	0.43±0.01
4	Vitamin C (mg/100g)	22.5±0.10	20.2±0.28
5	Lycopene (mg/100g)	4.13±0.15	3.35±0.01

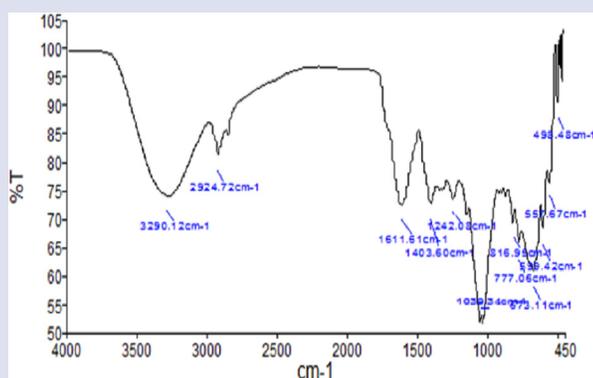


Figure 1: FT-IR spectrum for organic untreated tomato powder.

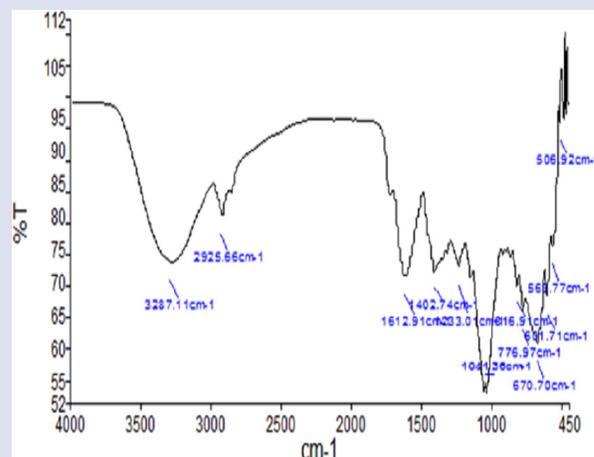


Figure 2: FT-IR spectrum for organic treated tomato powder.

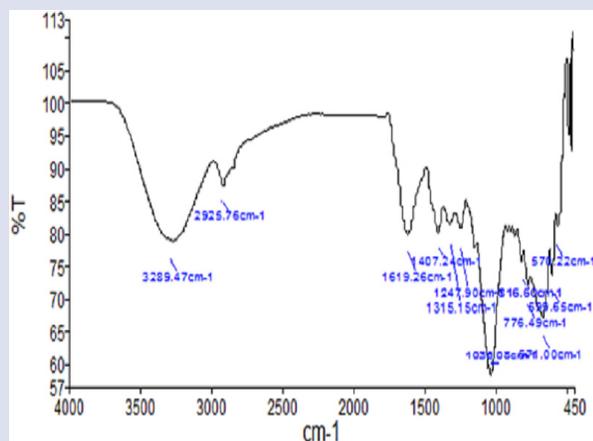


Figure 3: FT-IR spectrum for inorganic untreated tomato powder.

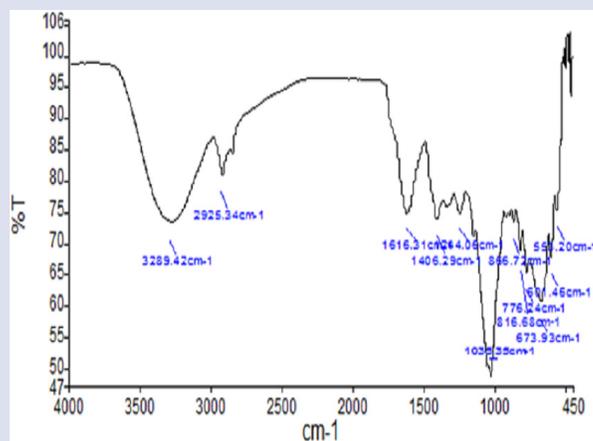


Figure 4: FT-IR spectrum for inorganic treated tomato powder.

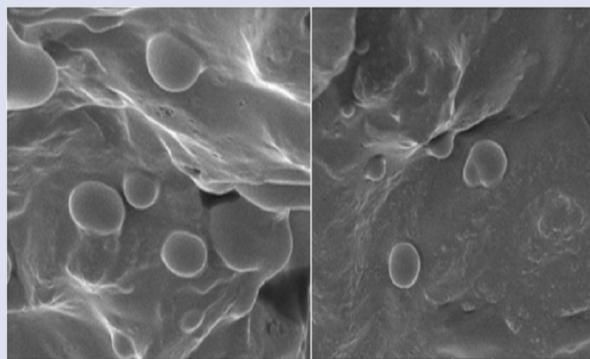


Figure 5: SEM micrograph for untreated organic tomato sample.

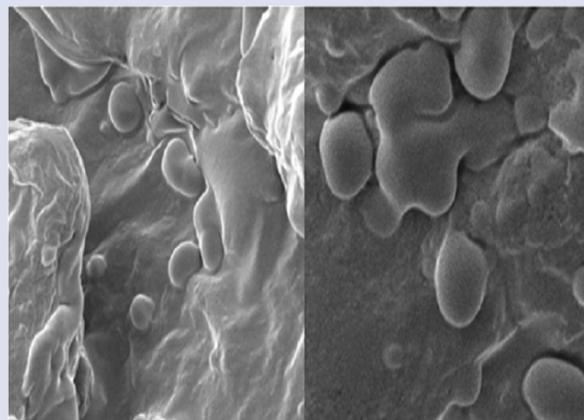


Figure 6: SEM micrograph for treated organic tomato sample.

Fourier transforms infrared spectroscopy (FTIR)

The FTIR spectroscopy was used to identify the functional groups of the active components present in organic and inorganic tray dried tomato powder in both control and UV treated condition based on the peak values in the region of IR radiation. The peak values of FTIR in all samples confirmed the presence O-H stretching, C-H stretching, C=O, C=C and C-OH groups respectively.

The study showed organic and inorganic tomato samples (control and treated), exhibited more or less same functional groups with considerable differences in peak values (Table 2 and Figure 1 to 4) which may be due to application of various pesticides, insecticides, fertilizers and other artificial chemicals, water source, soil condition and other residual effects in inorganic samples which varies in organic samples where some naturally occurring biological materials are used that influences direct or indirect changes in the functional groups. The presence of C-F group in inorganic untreated samples was found to be reduced considerably in UV treatment. Water treatment plants uses UV to disinfect water without any chemicals because of which taste, and other composition present may vary. Henceforth, UV showed positive results by retaining all functional compounds without losses.

FTIR spectra showed peak values at a 3290.12, 2924.72, 1611.61 and 1403.6 cm^{-1} in organic untreated, 3287.11, 2925.66, 1612.91 and 1402.74 cm^{-1} in organic treated, 3289.47, 2925.76, 1619.26, 1407.24 cm^{-1} in inorganic untreated and 3289.42, 2925.34, 1616.31 and 1406.29 cm^{-1} in inorganic treated samples. The analyzed peak value results were found comparable with ^{15,16} respectively. IR spectrum between 3100 and 3600 indicates the presence of It was evident that tomatoes are rich in alcohols, phenols (phenolic acids and flavonoids), carboxylic acids (amino acids), amides, alkynes and alkenes, henceforth, considered as a health promoter.

Scanning Electron Microscopy (SEM)

The morphological changes of organic and inorganic treated, and untreated tomato powder were investigated by using Scanning Electron Microscope (Figure 5 to 8). The results of the work reveal no significant/distinctive changes in both treated and untreated organic and inorganic samples. The surface structure of the images was almost similar in all cases; however, the effect of UV treatment was found to have a minimal effect on the structural changes of the tomato powder. Micrographs exhibited quite sticky surface with few spherical and elongated particles which may be due presence of moisture. Similar observations were

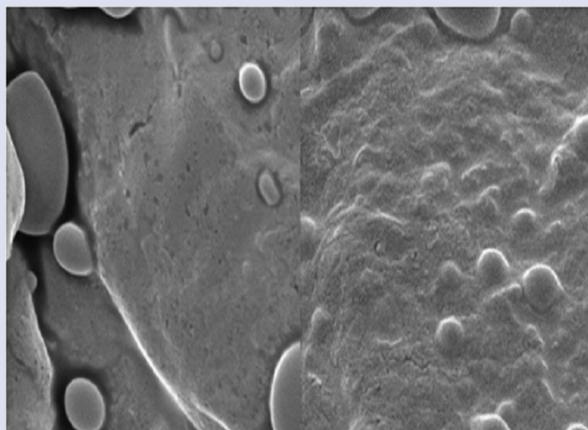


Figure 7: SEM micrograph for untreated inorganic tomato sample.

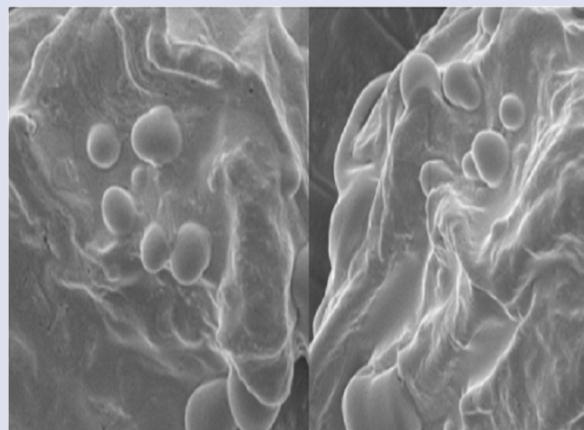


Figure 8: SEM micrograph for treated inorganic tomato sample.

noticed by,¹⁷ on reporting the temperature and moisture content effects on cohesion and flow ability of dairy powder. Reports also showed some caking phenomena in tomato powder which is time-temperature dependent.¹⁸

CONCLUSION

FTIR and SEM are well-established simple, sensitive, non-destructive technique that helps in rapid determination of functional groups and morphology in agricultural food products with accuracy. The results of the study showed the presence of strong and broad absorption bands of water, alcohols, phenols and carboxylic acids along with alkenes and amide (O-H, C-H, C=O, C=C and C-OH) at higher peaks respectively. Functional groups help in knowing the quality properties of tomatoes that need to be taken care right from farm to fork and offers a platform in understanding organic and inorganic tomatoes subjected to various processing conditions respectively. In SEM analysis distinctive changes were not observed and concludes presence of moisture content, treatments, drying temperature and uniformity in particle size, variety are deciding factors that influences morphological changes in tomatoes.

ACKNOWLEDGEMENT

The authors are thankful to Council of Scientific and Industrial Research (CSIR), New Delhi, India for funding this project.

ABBREVIATIONS

FT-IR: Fourier Transform- Infrared, **SEM:** Scanning Electron Microscope; **UV:** Ultra Violet.

CONFLICT OF INTEREST

There are no conflicts of interest.

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GRAPHICAL ABSTRACT



SUMMARY

- Tomato is considered as “protective foods” because of its special nutritive values which are very low in fat and have zero cholesterol level, with an excellent source of lycopene, carotene, anthocyanin, antioxidants, dietary fiber, minerals, and vitamins.
- The therapeutic properties of tomatoes (antioxidants) scientifically proved to be effective in fighting against cancers, including colon, prostate, breast, endometrial, lung, and pancreatic tumors.
- The present work has been performed to establish the various FTIR and SEM parameters, which creates a better platform in understanding and judging functional and structural changes between organic and inorganic tomatoes and role of UV by creating a commercial interest among farmers, processors and consumers.

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