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TRACE METAL ANALYSES OF RED TOMATO BY DIRECT CURRENT ARC OPTICAL EMISSION SPECTROSCOPY

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ABSTRACT

This work is planned to investigate the minerals (elements) present in the ripe red tomato by using the direct current arc optical emission spectroscopy technique (D.C. Arc OES). The ripe fruits are the rich source of minerals. The emission spectrum of the powder sample of the ripe red tomato has been acquired in the spectral region 300-900 nm at a resolution of 0.3 nm. The obtained spectrum shows the persistent atomic lines of the iron, molybdenum, calcium, potassium, strontium, tin, sulphur, sodium, barium, phosphorous, lithium and mercury which confirm the occurrence of these elements in the tomato sample. Curve fitting method has been applied for the determination of area of the spectral profile that has been used for the relative quantitative estimation of detected elements. A brief description of the role of detected elements in maintaining human health has been included.

KEYWORDS: Tomato, D C Arc Optical Emission Spectroscopy, Trace Metals, Vegetables

Elements are required by both plants and animals for their proper growth, development and maintenance of physiological activities. Each element in fixed proportion has a specific role in the metabolic events of the organisms. The imbalance of elements caused by any pathological, physiological stimuli, and environmental factors may impair the normal growth process of the body and lead to diseases. The environmental concerns like contamination of agricultural soil by heavy metals have necessitated the need to perform eco-toxicological effect of the metals on the vegetation. The uptake and accumulation of these metals in plants are known to cause several metabolic and physiological deformations in the plant species. In order to access the health status of an organism it is essential to analyze qualitatively and quantitatively these elements in their tissues (root, shoot, leaf, fruit) and organs using advanced rapid, sensitive and simultaneous element detection techniques that have high throughput. Vegetables contain large quantities of minerals, vitamins, carbohydrates, essential amino acid and dietary fibers that are required for the normal functioning of human metabolic processes. The elements have been reported to play a vital role in the formation of active chemical constituents in vegetables. Now-a-days edible vegetables have become a very potent therapeutic drug in tackling diseases. Though, most of the research work on plants and vegetables deals with the constituents such as essential oils, vitamins and other organic compounds, little attention has been paid on the elemental composition of the plant tissue. Minerals play a pivotal role in human life for healthy growth and maintaining health [1]. These metals are readily available in edible parts of plant tissue. Hence, screening of elemental composition of the widely used edible vegetables is highly important for determining their effectiveness in treatment of various diseases as well as understanding their action towards the maintenance of health of human being.

Tomatoes are scientifically known as *Lycopersicon esculentum*. They are excellent source of many nutrients and secondary metabolites that are important for human health, including mineral matter, vitamins, lycopene, flavonoids, organic acids, phenolics and other health-promoting natural compounds. Additionally, tomato fruits contain several antioxidants, such as vitamin C, carotenoids, phenolic compounds, flavonoids and phenolic acids. The presence of nutritive and toxic elements in tomato samples depends on the growing conditions and the utilization of pesticides and fertilizers. In addition, the accumulation of metals varies greatly both between species and cultivars [2, 3, 4].

Elemental composition of tomatoes is important to both consumers and health professionals, and in food quality control. Several analytical techniques such as inductively coupled plasma optical emission spectrometry [5], inductively coupled plasma mass spectrometry [6], flame atomic absorption spectrometry and electrothermal atomic absorption spectrometry [7], are being used for determining mineral contents present in the plant tissue samples. But all these techniques involved sample preparation involving time consuming, labor intensive and

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a long procedure of sample preparation such as acid digestion. Therefore, a technique which has the capability like rapid detection, multi-elemental and free from sample preparation is required [8]. One such technique is a direct current arc optical emission spectroscopy. The d c arc optical emission spectroscopy technique does not require sample digestion or dilution prior to analysis, cost effective, fast, sensitive, accurate, multi-elemental and eco-friendly technique. Due to these supremacies, author has decided to investigate the mineral present in the fruit sample. This account demonstrates the utility of the d c arc optical emission spectroscopy technique for the investigation of nutrients and toxic metals present in the ripe red tomato fruit.

MATERIALS AND METHODS

Elemental investigation of red tomato was carried out using direct current arc optical emission spectroscopy technique. The ripe red tomato fruits were procured from the local vegetable market of Allahabad. Then they were cleaned with tissue paper, washed with distilled water and dried at room temperature to avoid any surface contamination. The samples were burn in a hot air oven at a temperature of 75ºC for two days so that moisture and other organic elements are evaporated. Then they were powdered in a mortar and pestle arrangement. This powder was used as a sample for the elemental investigation. The experimental setup used for the recording of the arc spectrum of the powder tomato sample is shown in Figure 1. The arc was formed across a 0.5 cm gap between two carbon electrodes connected with d c voltage supply and ballast resistance. The arc current was controlled by the controlling (ballast) resistance and was ignited by mechanical contact of movable electrode with a sample. A small amount of the powder tomato sample (0.5 gm) was kept inside the cavity of the carbon electrode. The radiation was produced between two carbon electrodes connected with d c source. The excited sample emitted optical radiation. The emitted optical radiations were recorded using Photon Control Multichannel Fiber optic spectrometer equipped with three gratings and spec-soft MSS operating software in spectral region 300-900 nm at a resolution of 0.3 nm. In order to get intense signal about 10 scans were co-added together with integration time of 2 seconds and average intensity pattern was analysed with the help of origin 8.0 software package.

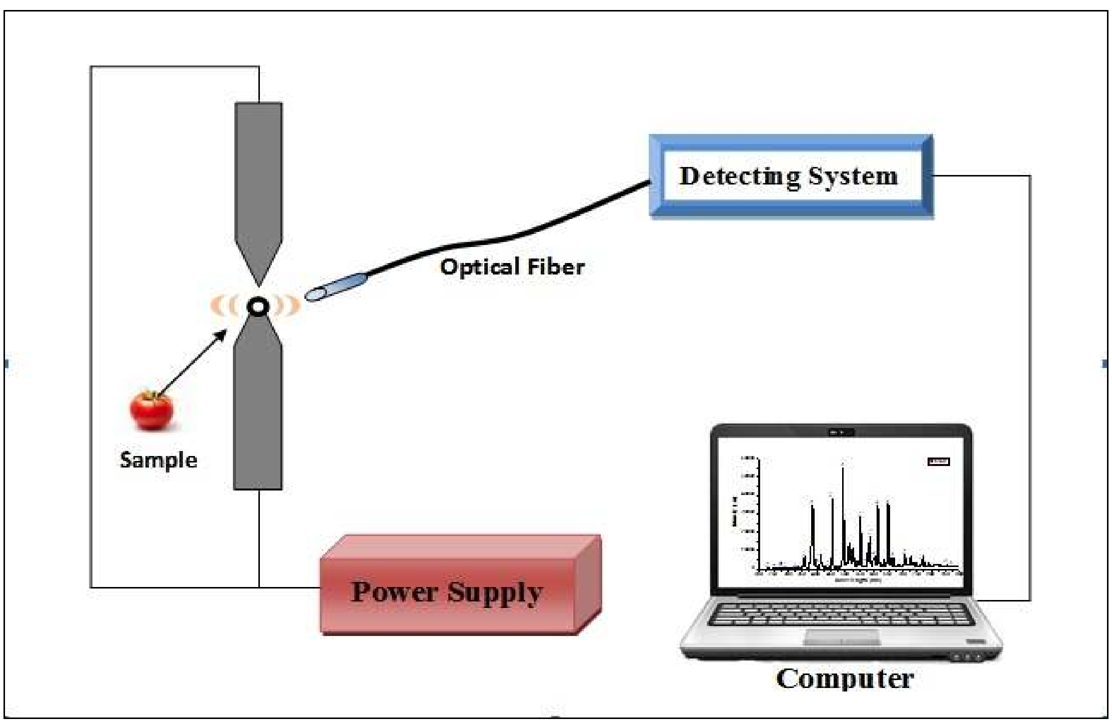

Figure 1: Experimental setup used for the recording of the direct current arc optical emission spectrum

RESULTS AND DISCUSSION

The recorded emission spectrum of powder of the red tomato in the spectral region 300-900 nm is reproduced in the Figure 2. The procured spectrum consists of spectral signatures of varying intensity of different wavelength thus showing the rich presence of elements in the ripe tomato. The wavelength of the spectral signature corresponds to the element present in the specimen while the intensity is proportional to the concentration of the respective elements. The spectral signatures have been identified with the help of NIST atomic spectral database [9]. The detected elements along with their wavelengths have been marked in the shown spectrogram (Fig. 2). The emission spectrum shows the persistent atomic lines of Fe (358.1, 385.9, 388.6, and 438.3 nm), Mo (386.7 and 553.3 nm), Ca (393.0, 396.8, 445.4, 610.2, 612.2, 616.2, 643.9, 649.3, 854.2 and 866.2 nm), K (404.7, 766.4 and 769.8 nm), Sr (407.7 and 640.8 nm), Sn (533.2 nm), S (543.2 nm), Na (588.9, 818.3 and 819.4 nm), Ba (614.1 nm), P (645.9 nm), Li (670.7 nm) and Hg (794.4 nm). The presence of persistent lines confirms the occurrence of these elements in the ripe red tomato sample.

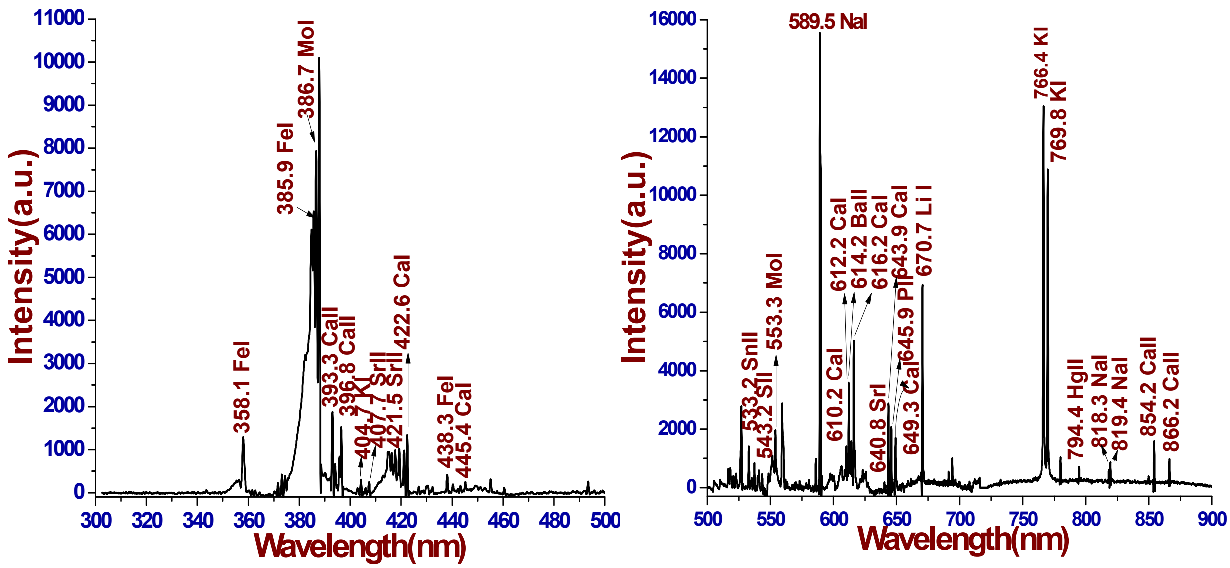

Figure 2: Recorded emission spectrum of tomato excited by d c arc optical emission spectroscopy

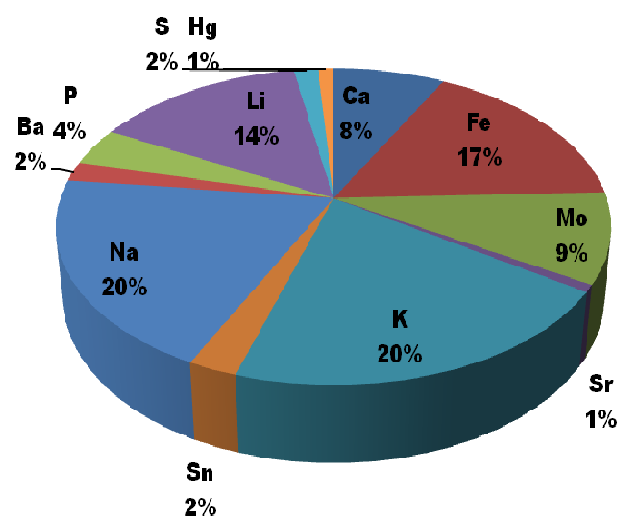

Figure 3: Relative distribution of determined elements in the Tomato (*Solanum lycopersicum*)

Semi-quantitative evaluation of detected elements in tomato has been extracted by Gaussian fitting of the recorded emission spectra. The peak area is a better indicator of concentration because the final peak profile consists of the effect of all the individual elements. In some cases, the peak height can be changed by broadening mechanism, but the area will remain unchanged as the total number of molecules remains constant. Therefore, curve fitting approach has been applied to estimate area of the spectral profile that gives the relative concentration of elements present in the tomato. The estimated fractional distribution of elements is determined as K (21%), Na (20%), Fe (17%), Li (14%), Mo (9%), Ca (8%), P (4%), Sn (2.4%), Ba (1.9%), S (1.7%), Hg (1.05%), and Sr (1%). The determined values are in same order as reported by previous workers using different techniques. The small deviation in determined values is due to varying environmental conditions.

Mineral elements play vital roles in many important processes in the body, such as iron, sodium, potassium, and calcium are important in human nutrition. The body requires iron for the synthesis of the oxygen transport proteins hemoglobin and myoglobin and for the formation of heam enzymes and other iron containing enzymes, which are particularly important for energy production immune defence and thyroid function. Iron and phosphorus are essential for most metabolic processes. This is nutritionally significant considering the fact that, potassium plays a principal role in neuro-muscular functions. In addition, sodium, potassium and calcium play an important role in the electrophysiology of cardiac tissue. Calcium-ions increase the force of contraction of the heart. Sodium maintains osmotic equilibrium between the extra cellular fluid and the tissue cells and maintains the pH of blood within normal limit. It is also concerned with the conduction of nervous impulses, muscle contractility and control of heart muscle conduction. Lithium is naturally found in tomatoes. It is absorbed in the intestinal tract (small intestine) through the sodium channel, and is excreted through the kidneys. One of the most important roles of lithium in the body is regulation of serotonin; serotonin is regarded as a natural antidepressant. Lithium also affects the transport of sodium in the body, increases lympholitic proliferation and thus increases immunity. Molybdenum is found in the body in very small amounts, but its role is important in many biological processes including development of the nervous system, dispersing waste substances from the body through the kidneys and the production of energy in cells. It acts as a co factor in many enzymatic activities. Tin is considered a trace mineral while barium and mercury are non essential elements for human nutrition. Their presence in tomato is not significant.

CONCLUSION

The present investigation demonstrates potential of the direct current arc optical emission spectroscopy for the determination of minerals present in the ripe fruit of tomato. It is an excellent choice for elemental screening due to its short analysis time, minimal sample preparation, multielemental capability, ecofriendly and cost effective nature. The investigation of red tomato yields the rich presence of nutrients potassium, sodium, calcium, iron, lithium, molybednum, phosphrous, sulphur, strontium, and tin along with non-essential elements barium and mercury. Therefore the level of the content of the tin and barium must be regulated to avoid any kind of harmful effect in long run.

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