Acoustic measurements on fruits

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Abstract: - Fresh fruits and vegetables are important due to their health properties. They provide vitamins, minerals and fiber to help keep our body healthy. Because of the contaminated soils around urban environments, occasionally, fresh fruits and vegetables can become contaminated with polluted air and could lead to serious health issues. On the other hand, when fruit are exposed to low doses of UV a typical response to stress has been observed. In this research, the measurements were concentrated on the potential of CO2 laser photoacoustic spectroscopy in the analysis of red fruits cherry tomatoes exposed to pollution from various car engines and UV radiation. The results were correlated with red fruits cherry tomatoes exposed to nitrogen air flow (anaerobic conditions) with red fruits cherry tomatoes exhibited normal aerobic conditions (synthetic airflow). With the advantages of laser photoacoustic spectroscopy technique, we showed that red fruits cherry tomatoes under pollution, emit more ethylene gas than those under UV radiation.

Key-Words: - Photoacoustic, ethylene, pollution, UV radiation, laser, spectroscopy

1 Introduction

Ethylene gas is a major plant hormone that influences diverse processes in plant growth, development and stress responses throughout the plant life cycle. Ethylene is produced essentially from all parts of higher plants, including leaves, stems, roots, flowers, fruits, tubers and seeds. Ethylene production is regulated by a variety of developmental and environmental factors. Analytical detection of the plant hormone ethylene is an important prerequisite in physiological studies.

Generally, ethylene production rates increase with maturity at harvest, physical injuries, disease incidence, increased temperatures and water stress. On the other hand, ethylene production rates by fresh produce are reduced by storage at the lowest safe temperature and by low oxygen or elevated carbon dioxide levels [1].

Another source of ethylene production is from air pollution due to burning of coal, oil, or natural gas in industrial uses; refuse burning; operation of internal combustion engines (motor vehicles, for lifts, etc.); decomposing plant materials; cigarette smoke; fluorescent lamp ballasts; etc [1-3]. These metabolic disturbances (toxicity, temperature, engines pollution, UV irradiation etc.) in fruit are followed by significant and rapid changes in the rate of ethylene response.

Engines pollution influences the activities of ethylene plant hormones and growth regulators, which affect developing tissues and normal organ development, without causing leaf-tissue damage.

UV radiation can provoke an appreciable enhancement of ethylene emission. Higher radiation doses correspond to increase ethylene production. Increased ethylene production appears to be a typical response to stress and simultaneously, one of the traits of plants resistance to UV radiation.

There are a number of methods, which can be used to determine ethylene levels from plants, fruits and vegetables.

Real-time and super sensitive detection of trace amounts of ethylene gas is possible using laser-based photoacoustic spectroscopy.

As an application, our study is based on the detection of the ethylene concentration in red fruits cherry tomatoes using CO_2 laser spectroscopy technique [4].

Because the spectrum of CO_2 laser overlap, at room temperature and normal atmospheric pressure, for the absorption spectra of ethylene, a good choice is to use a frequency-stabilized CO_2 laser and a photoacoustic cell (PA cell), in monitoring the evolution of ethylene [4, 7].

2 Method

The emitted ethylene concentration measurement is analyzed by laser photoacoustic spectroscopy technique, as it offers a high sensitivity.[5, 9]. To test the cherry tomatoes exposed to engines pollution and UV radiation, we operate a sensitive instrument and we report, the ethylene vapors from exposed fruits, measured at the CO_2 laser wavelengths in precisely controlled experimental conditions.

The following important parameters were used throughout the experiments for the detection of ethylene gas at cherry tomatoes: biological sample cuvette pressure: ≈1024 mbar; responsivity of the PA cell: 433 cmV/W; synthetic air: Linde Gaz Romania, 20% oxygen and 80% nitrogen (impurities: hydrocarbons max. 0.1 ppmV, nitrogen oxides max. 0.1 ppmV); working laser line: 10P(14), where we have a maximum absorption coefficient for ethylene: λ= 949.479 cm-1 , α= 30.4 cm-1atm-1; operating temperature: 23–25 ^{o}C; glass cuvette total volume: ≈150 mL; PA cell total volume: ≈1000 mL; biological samples analysis time: ≈3 minutes.

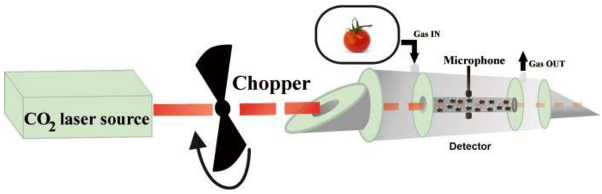

Fig. 1. Configuration of the IR spectroscopy system for red fruits cherry tomatoes sample testing

The continuous wave CO_2 laser is frequency stabilized emitting radiation in the 9.2 - 10.8 μm region with a maximum power of 6.5 W. The CO_2 laser beam is modulated in intensity by a high quality low vibration noise and variable speed mechanical chopper operating at the appropriate resonant frequency of the cell (564 Hz), is focused by a ZnSe lens, and then is introduced in the photoacoustic cell. The resonant photoacoustic cell was developed to monitor different gases. In the resonator tube wall carefully are embedded four microphones where the acoustic wave is detected and generate a corresponding signal (voltage) which is fed into a lock-in amplifier. The lock-in amplifier gives the amplitude and the phase of the photoacoustic signal synchronized to the chopper phase. The amplitude of the photoacoustic signal is proportional with the concentration of the absorbing molecules. A powermeter measures the laser beam power after the photoacoustic cell. Its digital output is introduced in the data acquisition interface module together with the output from a lock-in amplifier. All experimental data are processed and stored by a computer. The modular software architecture aimed at controlling the experiments, collecting data, and preprocessing information. It helps to automate the process of collecting and processing the experimental results.

3 Results and discussiona

The red fruits cherry tomatoes were obtained from local farmers and transported to the laboratory were we selected and evaluated the fruits only at harvesting stage/ red fruits (50 g).

All fruits used in these measurements were stored at 40C for subsequent use.

Before starting the analysis of cherry tomatoes (expressed in grams), all fruits were acclimatized over 1 h at room temperature (23 - 25 ^{0}C) and then introduced into a small glass cuvette (with volume of 150 cm^3) to be exposed for 25 min to pollution from various car engines and 25 min to UV radiation at 365 nm with the lamp power of 8W.

The CO_2 laser photoacoustic spectroscopy system was first used to quantify the level of ethylene that is normally produced by cherry tomatoes fruits in normal aerobic conditions (synthetic air flow) compared to anaerobic conditions (nitrogen air flow).

Fig. 2 presents the production of ethylene experimentally measured for 50g of red cherry tomatoes fruits.

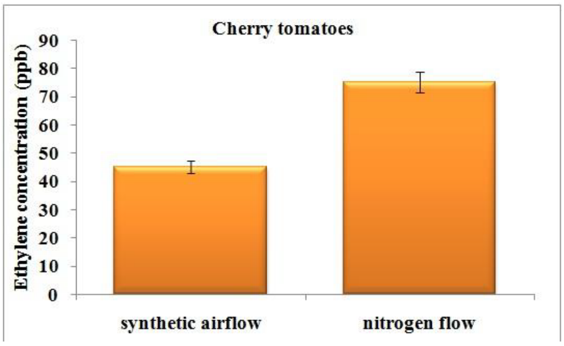

Fig. 2. Ethylene vapors at cherry tomatoes fruits produced in aerobic vs. anaerobic conditions

We observed the increased of ethylene concentration when we exposed the red fruits in

anaerobic conditions compared to normal aerobic conditions.
In addition, Fig. 3 shows ethylene vapors from cherry tomatoes exposed 25 min to pollution from various car engines and 25 min to UV radiation.

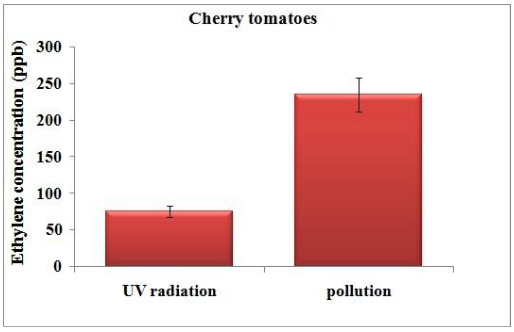

Fig. 3. Ethylene vapors at cherry tomatoes fruits produced after 25min exposure to UV radiation and after 25min exposure to pollution

We can observed from the determinations that cherry tomatoes under stress emit more ethylene gas (rises by more than 400% when are exposed to pollution) than those under normal conditions.
Such differences could originate from limitations to growth imposed by the stress in these two environmental conditions, prevailing in fruits exposed to pollution and UV radiation.
The higher level in ethylene response confirms that oxidative stress was higher in cherry tomatoes fruits exposed to UV radiation and pollution than in fruits exposed to aerobic conditions.

4 Conclusion

In the present research, tests were made to determine if the cherry tomatoes fruits exposed to UV radiation and pollution release more ethylene gas compared with normal ones.
Our determinations demonstrated that exposed red fruits at pollution, determine a greater increase of ethylene vapors in the respiration of cherry tomatoes after 25 min of exposure. The level of the ethylene was about 400% higher for red fruits in pollution conditions than for red fruits in normal conditions.
The higher level in ethylene vapors confirms that stress, was higher in exposed fruits at anaerobic conditions (e.g. UV radiation and pollution) compared to fruits in normal conditions, which could induce the degradation in cherry tomatoes fruits.
The tests demonstrates that CO_2 laser photoacoustic spectroscopy is an important tool for sensitive and selective detection of ethylene molecules at cherry tomatoes fruits and can play an important role in testing the contaminated vegetation in particular fruit quality.

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