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ETHYLENE PRODUCTION OF ORGANIC AND NONORGANIC MATURE MUSHROOMS MEASURED BY LPAS

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Abstract. We have examined the potential of laser photoacoustic spectroscopy (LPAS) as a sensitive method for trace gas detection by assessing the champignon mushrooms quality, focusing the attention on quantitative determination of ethylene released by organic and nonorganic mature mushrooms. With the advantages of LPAS, it is observed that quantitative changes in production of ethylene occur in the respiration of nonorganic mature champion mushrooms compared with organic ones.

Key words: mushrooms, ethylene, organic, nonorganic, laser photoacoustic spectroscopy.

1. INTRODUCTION

Mushrooms (*Agaricus bisporus*) belong to the family of Fungi, a group very distinct from plants, animals and bacteria. Fungi lack the most important feature of plants: the ability to use energy from the sun directly through chlorophyll. Thus, fungi depend on other organisms for nutrition, absorbing nutrients from the organic material in which they live. The living body of the fungus is mycelium made out of a tiny web of threads (or filaments) called hyphae. Under specific conditions, sexually compatible hyphae will fuse and start to form spores. The larger spore producing structures (bigger than about 1 mm) are called mushrooms. In nature this is the most prominent part of the organism, but in fact this is just the fruiting body and the major part of the living organism is found under the ground or inside the wood [1, 2].

Plants and microbes naturally produce ethylene (a colorless gas) that can act as a plant growth regulator hormone. Plants respond to environmental variations and stresses by modulating both the production of and response to ethylene. On a global scale, it has been estimated that 18 to 45 × 10^6 tonnes are released annually into the atmosphere [3], of which 74% is attributed to natural sources and 26% to

anthropogenic sources. Of the anthropogenic portion, 77% is attributed to biomass burning, while 21% is attributed to the burning of fossil fuels [3, 4].

Ethylene in plant tissues can either influence or be influenced by other plant hormones. For example, increased ethylene concentrations can induce the production of giberellic acid [5]. Alternatively, ethylene production can be induced by auxin [6, 7]. Induced ethylene can regulate leaf abscission, epinastic growth, or play a role in developmental processes such as bud formation and growth, promotion or inhibition of flowering, feminization, and senescence [3, 6]. All tissue types and probably all cells of higher plants produce and liberate ethylene [7].

In this paper, ethylene gas was identified as the product of mushrooms using LPAS technique to quantify and compare the organic with nonorganic mature champignon mushrooms. We report quantitative measurements of this gas, and set out evidence from which we conclude that a higher production of ethylene reflects nonorganic mature mushrooms.

2. METHOD

To test the quality of organic and nonorganic mushrooms, we analyzed the amount of ethylene by using the LPAS method (Fig. 1), because it is one of the most used approaches for sensitive and selective trace gas detection and it can routinely detect trace gases quantities down to 1 ppb (parts per billion).

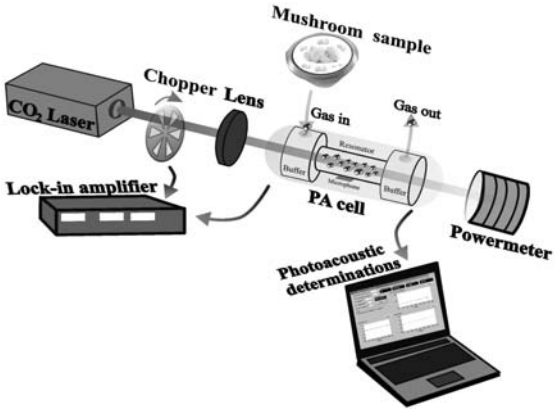

Fig.1 – The LPAS system with the sample glass cuvette used to contain mushrooms.

Immune to interference, high accuracy and precision, minor sample preparation, good temporal resolution, ease of use, versatility, reliability, robustness, and a relatively low cost per unit make LPAS technique functional in a large dynamic range for measurement of trace gases [3]. Here it is used to detect ethylene emission from mushrooms.

The experimental setup consists of a line-tunable and frequency stabilized CO_2 laser. This laser, emitting radiation in the 9.2–10.8 μm region on 73 different vibrational-rotational lines, has a maximum power of 6.5 W on the 10P(20) line. The requirement for gases to be detected with this laser is that they should possess relatively high absorption strength and a characteristic absorption pattern in the wavelength range of the CO_2 laser. For ethylene, the largest absorption is attained at 10P(14) line of the CO_2 laser (10.53 μm) [8–10].

The home made PA cell, equipped with 4 sensitive microphones, has a responsivity, one of the largest value [10] reported in the literature. Traces of ethylene released by various champignon mushrooms samples absorb laser radiation inside the photoacoustic cell (PA) and the ethylene concentration is determined after the calibration of the PA cell responsivity is made [10].

The following important parameters were used throughout the experiments for the detection of ethylene gas:

– Mushroom cuvette pressure: ≈ 1024 mbar;

– Responsitivity of the PA cell: 440 cmV/W;

– Synthetic air: Linde Gaz Romania, 20% oxygen and 80% nitrogen (impurities: hydrocarbons max. 0.1 ppmV, nitrogen oxides max. 0.1 ppmV);

– Nitrogen: Linde Gaz Romania, nitrogen 5.0 (purity 99.999%) and 6.0 (purity 99.9999%);

– Working CO_2 laser line: 10P(14), where we have a maximum absorption coefficient for ethylene: $\lambda = 949.479\ cm^{-1}$, $\alpha = 30.4\ cm^{-1}atm^{-1}$;

– Operating temperature: 23 - 25^0C;

– Glass cuvette total volume: ≈150 mL;

– PA cell total volume: ≈1000 mL;

– Mushroom samples analysis time: ≈ 3 minutes.

To increase the accuracy of the measurements for the analysis of ethylene in mushrooms, we took several supplementary measures, such as glass cuvettes (used to contain mushrooms) for preserving the sample gas and a trap filled with potassium hydroxide pellets (KOH) for prevention of possible inhibition of samples by accumulation of CO_2 [11, 12].

To analyze the mushroom glass cuvette contents, firstly we evacuated thoroughly the previous gas mixture from the entire handling system, including the PA cell, traps, pipes etc., and then we cleaned the system for few minutes. After a second vacuum cleaning, the gas from the mushroom sample was transferred in the PA cell and analyzed.

Regardless of the champignon mushroom glass cuvette chosen, the system of sample collection must be carefully checked to ensure that there is no ethylene loss (leakage, decomposition, adsorption to the sample cuvette), or generation of ethylene as a result of chemical reactions within the cuvette. If the sample cuvettes are to be reused, it is equally important to ensure that the cuvettes do not have an ethylene memory (release of ethylene adsorbed onto the inner lining into

subsequently collected samples). Possible accumulation of ethylene was prevented by washing the glass cuvette with nitrogen (it is a pure clean non expanding inert gas) at atmospheric pressure for few minutes.

3. RESULTS AND DISCUSSIONS

We have examined 4 mature organic and nonorganic champignon mushroom samples in synthetic air flow and nitrogen flow at atmospheric pressure.

Nonorganic champignon mushroom samples (33–35 g) were obtained from international dealers (supermarkets), produced in European countries.

The organic or nonorganic mushrooms used in these measurements were stored at 4°C for subsequent use. Before starting the ethylene determination, all mushrooms were acclimatized over 1 h at room temperature (23–25°C) and then introduced into a small glass cuvette (with a volume of 150 cm^3) for measurements.

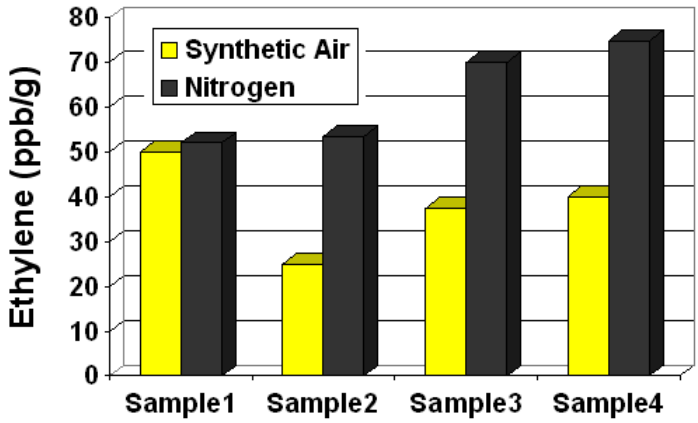

Fig. 2 – Ethylene amount in nonorganic champion mushrooms.

Organic champignon mushrooms cultivated organically were obtained from a local farmer (near Bucharest) and transported to the Laboratory for analysis. The organic cultivation area for harvested mushrooms was treated only with compost of animal manure (natural fertilizers) and the mushrooms were sorted, evaluated (at harvesting stage) and expressed in grams (between 33 g and 35 g).

The results from Figs. 2 and 3 illustrate that when we applied nitrogen flow to organic and nonorganic champignon mushrooms (compared with synthetic air flow), the ethylene production is forced and starts to rise. Nitrogen can be one of the most critical nutrients in mushrooms production and can create quality problems promoting excessive development that depresses the organic and nonorganic Fungi.

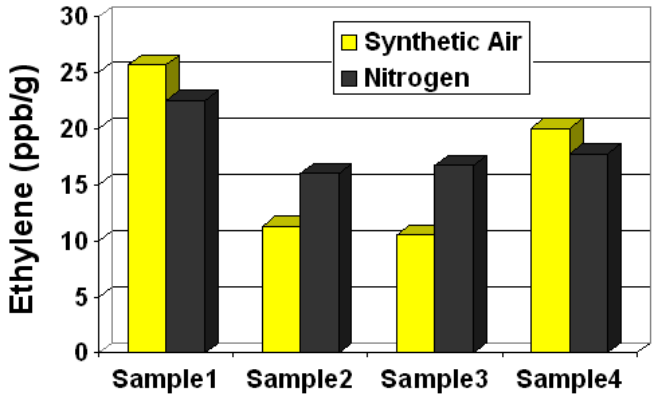

Fig. 3 – Ethylene amount in organic champion mushrooms.

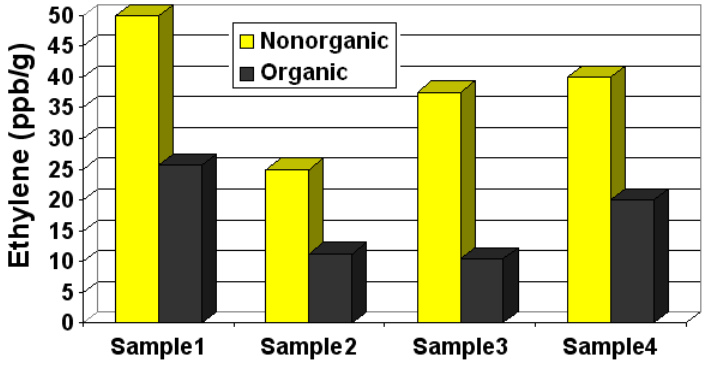

Fig. 4 – Ethylene amount in synthetic air at organic and nonorganic champion mushrooms.

As a second observation of our measurements for all the mushrooms in synthetic air flow (Fig. 4), we concluded that for all samples controlled with natural methods (organic), the ethylene level is lower compared to all champignon mushroom samples from supermarkets (nonorganic), where the concentration of ethylene rises by more than 100%.

4. CONCLUSIONS

In the present research, measurements were made to determine if the nonorganic champion mushrooms release more ethylene gas compared with organic ones. We assessed the effect of nitrogen flow in champion mushrooms quality using LPAS method.

Our measurements demonstrated that nonorganic mushrooms determine a greater increase of the ethylene concentration in the respiration of Fungi. As we

can see in Figs. 2, 3 and 4, there were quantitative changes in ethylene production between the mushrooms harvested from the two growing systems (organic and nonorganic). The level of the ethylene was about 100% higher for nonorganic mushrooms than for organic mushrooms farming. Such considerable differences could originate either from differences in nitrogen availability or from limitations to growth imposed by the more stressing conditions (like irradiation, toxicity or growth hormone) prevailing in nonorganic farming.

The results showed that the LPAS system could play an important role in testing the quality of mushrooms being able to distinguish between organic and nonorganic Fungi samples.

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