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AN EFFICIENT, COMPETITIVE "OZONE GENERATION SYSTEMS" FOR THE CHALLENGES IN AGRICULTURE SECTOR

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ABSTRACT

The Paris agreement besides issues related to mitigation of warming, adaptation to climate change and climate finance, recognizes the fundamental priority of food security and hunger eradication and the particular vulnerability of food production systems, also the sustainable consumption and production rules and models.
The Directive 2009/128/EC of the European Parliament and of the Council establishes a framework for achieving the sustainable use of pesticides, reducing the risks and impacts of pesticide use on human health and the environment, and promoting integrated pest management and the use of alternative, by non-chemical approaches or techniques for pesticides. The European Commission's plan calls for a 50% reduction in pesticide use over the next decade, and by 2030 the reduce the sale of antimicrobials to farm animals by 50% and 20% the use of fertilizers. The share of organic farming will also increase by 25% from the current 10%.
The presented article considers the solution of problems in various spheres of the national economy, through an innovative energy and cost-effective ozone generation system as an alternative to expensive and non-ecological disinfectants and pesticides.

KEYWORDS

Ozone, Eco Friendly, Energy Efficient, Cost Efficient, Disinfection

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Introduction.

The increasing use of toxic chemicals and pesticides in agriculture can further reduce crop quality and yield and affect soil productivity, especially in the world's most fragile regions. At the same time, our food systems account for about 34 % of greenhouse gas emissions [1].

Healthy, sustainable and inclusive food systems are critical to achieving global development goals, where agriculture and its development are one of the most powerful tools for poverty alleviation, as well as critical for economic growth.

Current food systems also threaten the health of people and the planet and create unacceptable levels of pollution and waste. Today, the risks associated with unhealthy diets are also the leading cause of death worldwide. About 3 billion people in the world cannot afford healthy food [2].

Green Revolution did not reduce hunger Increased hunger appears to have resulted from unequal access to food and food production resources. Experts conclude that industrial farming destroys soil quality, decreases yields, because chemical fertilizers are not a sustainable source of soil fertility. In the long term, these methods contribute to groundwater depletion [3].

The rise of pests and growing resistance is not surprising given that 3 billion kg. of pesticides are used worldwide each year [4]. Other aspect of the pesticide problem is the harm to human health.

General Problems.

According to a groundbreaking analysis by the Food and Agriculture Organization of the United Nations (FAO), the "hidden costs" of agriculture and food systems could be as high as $10 trillion a year - nearly 10% of global GDP. Among them, more than 70% are related to unhealthy nutrition of the population [5].

Despite the colossal global pollution of the environment with pesticides, the negative impact on human health, the constant and increasing direct and so-called "hidden costs" of industrial and agricultural use, to provide sufficient and healthy agricultural products for the growing population, there is still no known alternative to pesticides, energy and A cost-effective, non-chemical alternative.

Meanwhile, chemical pesticides, commonly used to maintain crop yields, are a factor in biodiversity loss, poor water intake, degraded soils and increased pest resistance, and are also linked to the emergence of chronic diseases.

The advantages of alternatives compared to traditional ones can be summarized as follows: yield increase by 50-100%, stable overall production level compared to industrial systems [6], resistance to pests and other environmental benefits.

In agriculture, the purpose of poisonous chemicals and pesticides is to fight pests, fungi and other diseases. This is especially true for industrial production. Deodorization, water and air disinfection, disinsection, deodorization, decontamination of sewage and gas-chemical emission and organic waste, long-term storage of agricultural and food products, use of non-ecological poison-chemicals and pesticides are very expensive procedures, causes and has a direct negative impact on the economic results of the business.

An alternative to poison chemicals and pesticides is ozone, both in gas and aqueous state. It is known that ozone (O_3) is a triatomic, allotrope form of oxygen, which is a strongly reactive (less stable) and powerful versatile oxidizing agent, which is characterized by antiviral, antimicrobial and anti fungal activity, it is ecological, it does not cause the formation of carcinogenic substances and by-products, the induced-oxidative stress in living tissues causes an antioxidant reaction, and therefore ozone can be considered as an abiotic agent, so it can be considered as a universal disinfectant.

Unlike poison-chemicals and pesticides, the possibilities of ozone for food and agriculture: Disinfection of grain and food [7], fruit and vegetable, dairy products. [8], meat [9,10], for fish farming [11], food safety and sanitation, in the water bottling industry [12], for vineyard, wine and beer [13,14]. Hydroponics, irrigation, drinking water of farm animals and odour control, soil remediation [15], disinfection of facilities and equipment, waste water treatment [16,17]. etc.

Within the framework of the research grant project of the National Science Foundation of Georgia Shota Rustaveli, with the support of the Technical University of Georgia, on the target group selected in the vineyards of the Small Wine Producers Association of the Bolnisi region, the research conducted for 2 years on the use of aqueous ozone solution in viticulture, refined the technology of its use, confirmed the expectations and obtained the desired results:

1. Ozone concentration in water at 0.03 mg/l is the minimum allowable indicator at 20-30 ^{0}C-temperature (while flowering is used in cases of particularly bad weather);

2. Ozone concentration in water at 0.05 mg/l is an optimal indicator at a temperature of up to 25 ^{0}C, during average periodic rains;

3. Ozone concentration in water at 0.06 mg/l is an optimal indicator at a temperature of up to 20 ^{0}C, in the period of frequent rains;

4. The concentration of ozone in water at 0.09 mg/l is the critical maximum allowable level, which damages vine leaves and culture;

5. It was determined that vines should be treated with ozonized water solution before the appearance of diseases, for the purpose of prevention. (7-10-14-21 once a day, depending on the weather).

6. Ozone-treated grape leaves, which contain the best spectrum of specific microelements, are ideal bio-fertilizers for the same grape variety, that is why they are processed with Georgian wormwood, whose coprolites as a bio-fertilizer are a world innovation for the sustainability of vineyard soil fertility and strengthening the immune defense system of the grape variety and its to create fertility stability.

7. Macro and microelements were determined in grape leaves. Sample preparation and content measurement was carried out in the Atomic Absorption Spectrometry Department of the Academician Nodar Kekelidze Scientific Research Institute of Materials Research of the Faculty of Exact and Natural Sciences of Ivane Javakhishvili Tbilisi State University, on an atomic absorption spectrometer AAnalyst 800 (PerkinElmer Inc.) with software WinLab 32 and in the "Geoanalytic" laboratory of the Alexandre Tvachrelidze Mineral Resources Caucasus Institute. It was determined some mineral microelements and macroelements in grape leaves (tables 1 and 2 accordingly).

It was determined also the content of resveratrol and quercetin in the leaves, because of due to the high antioxidant activity of resveratrol, as well as anticarcinogenic, antiviral, anti-inflammatory, cardioprotective activity, and quercetin that helps to reduce cholesterol. The definition of resveratrol and quercetin content were carried out by HPLS method on Agilent 1200 Teechnologies chromatograph (fig. 1). The content of resveratrol in leaves reaches 3.4 mg/kg and content of quercetin 13.5 mg/kg. The target of this work is to create a complete cluster of macro-micro-ulrtamicro-elements in healing wine, both for adults and children, by removing ethanol from the same bio-wine.

Table 1. Some mineral microcomponents content in leaves, mg/kg.

N	The name of the grape	Ni	Cd	Cu	Pb	Mn	Co	Zn	Cr	Fe common
1	Saperavi	27.32	0.56	9.32	1.38	564.5	2.64	7.77	1.75	352,8
2	Chinuri	25.46	0.52	9.41	4.82	120.75	2.44	4.95	2.34	560.0
3	Rqatsiteli	26.98	0.55	9.65	4.84	61.0	2.35	5.75	1.95	266.0

Table 2. Content of macroelements in leaves, mg/kg.

N	The name of the grape	Ca	Mg	Al	K	Si	P	S
1	Saperavi	32000	4800	270	6300	7354.7	580	988.56
2	Chinuri	28000	8000	450	4378	7214.7	260	1215.11
3	Rqatsiteli	32000	4800	<20	2450	5180.0	280	1160.19

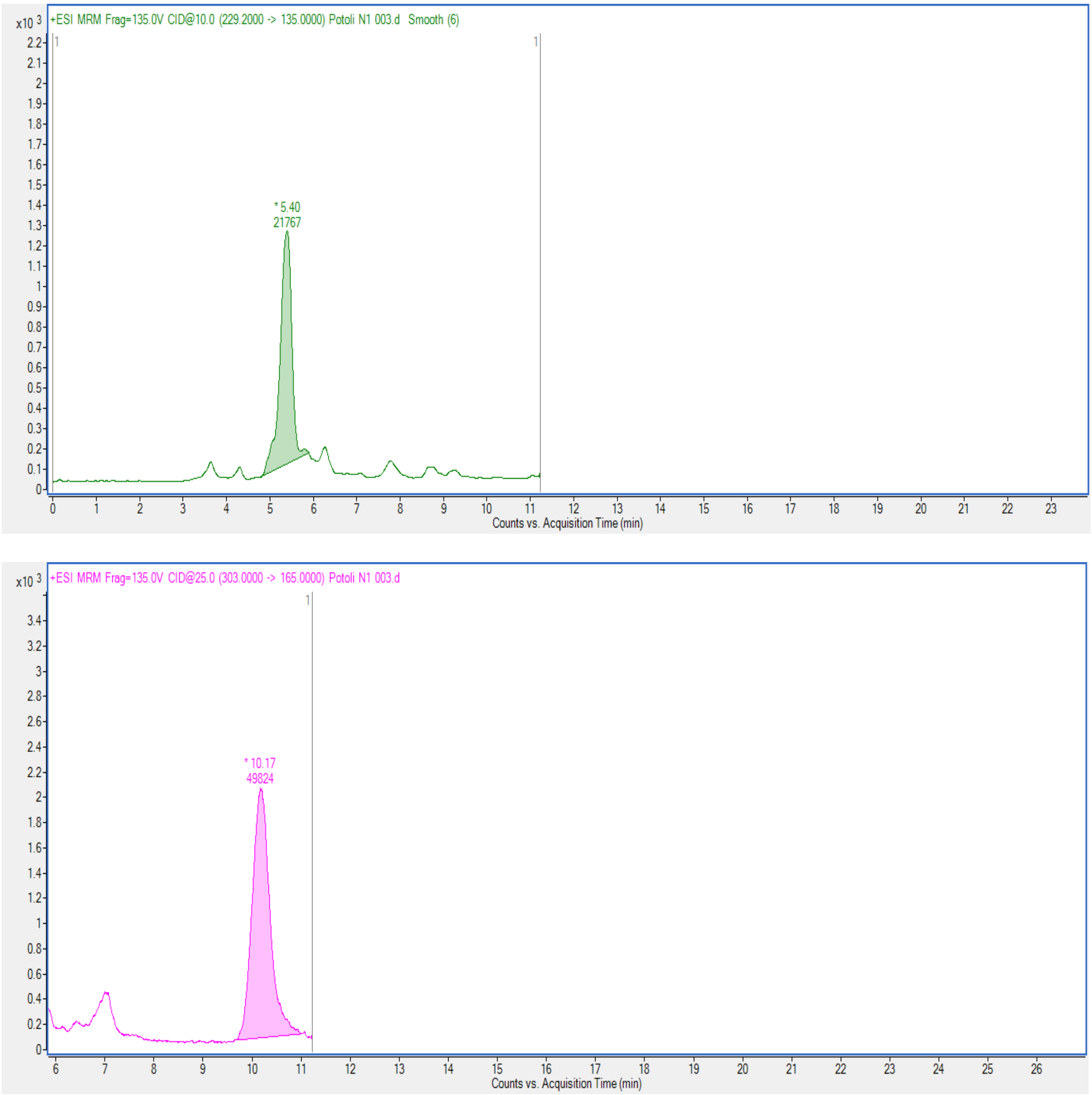

***Fig. 1.** The chromatograms of resveratrol and quercetin, contained in grape leaves.*

Methodology.

The most common methods of generating Ozone are of two types:

1) Using ultraviolet radiation;

2) Electric discharge between two electrodes. The main problems of mass production are:

a) High cost of technology; b) High energy consumption.

The company "Hydrogen Technology" has created a competitive, simple, durable, energy-efficient and cost-effective "ozone generation system" (Patent of the National Intellectual Property Center of Georgia P 2021 7302 B; WIPO).

The product of the present invention is an ozone generation system that is durable and reliable, does not damage the electrode due to the current released during the electrical discharge, is capable of operating at a reduced voltage of the power source, and operates efficiently, consuming relatively less energy.

The apparatus for producing ozone comprises: an ozone generating camera with gas inlet and outlet means; first and second electrodes disposed within the ozone generating camera in a concentric relationship with each other and spaced apart by a dielectric barrier, the barrier made as a transparent tube to the ultraviolet light; the tube has electric terminals at its ends and filled with a gas for creating plasma within the tube upon applying electric voltage to terminals; the first electrode made as a wire wound around said dielectric barrier; and the second electrode made as a plasma created within tube upon applying electric voltage to terminals at its ends; the plasma is capable of radiating ultraviolet light and creating white noise consisting of various frequencies.

The apparatus comprises electric powering means for applying voltage to the first and second electrodes, the voltage have the chaotically modulated distorted sine waveform so as to have Fourier series of harmonic frequencies and to establish resonance with frequencies generated by plasma created within tube.

There is constructed a simplified theoretical model not chaotic modulation but as nesting sine function and analysis it with Fourie series numerical model:

$$g(t) = A\sin[\omega_c t + B\sin(\omega_m t + \varphi)] \qquad (1)$$

Where: A: Amplitude of the carrier signal; B: Amplitude of the modulating function; ω_c Frequency of the carrier signal; ω_mFrequency of the modulating function; φ: Phase angle.

Directly finding the Fourier series representation of this function might be complex due to the nested sine functions, so it used numerical methods or approximations to find coefficients for each term. The first the Bessel function was used to express the modulated term $B\sin(\omega_m t + \varphi)$ as a Fourier series. Then we substitute this into the original function and proceed with finding its Fourier series representation.

The modulating term can be expanded as: $B\sin(\omega_m t + \varphi) = \sum_{n=o}^{\infty} C_n J_n(\alpha t)$

where: $Jn(\alpha t)$ is the Bessel function of the first kind of order n, and C_n are the Fourier-Bessel coefficients.

To find the Fourier-Bessel coefficients C_n, we'll use the formula:

$$C_n = \frac{2}{T}\int_0^T B\sin(\omega_n t + \theta) J_n(\alpha t) dt \qquad (2)$$

Where; T is the period of the function.

Here is computed the Fourier-Bessel coefficients cnusing Simpson's rule for numerical integration. This simplified theoretical model gives results that show that additional frequencies in energy supply for the device give, terms with resonant in Fourie series with higher amplitudes and well fit with an experimental investigation for effective energy supply for original ozone generator.

In invention one of the two electrodes, particularly as the inner one, plasma is used. This type of electrode is a gas comprising evenly distributed ions and electrons constituting the plasma confined in a dielectric glass tube so as to not escape. It has high electrical conductivity and an electric current does not enter the inside of plasma.

It is apparent that the plasma itself is an efficient source of ultraviolet radiation. It has been observed that due to the effect of ultraviolet radiation, the dielectric material, such as the quartz tube, changes its properties, namely its electrical conductivity, which establishes more favorable conditions for gas discharge within the ozone-generating device according to the present invention. This eventually minimizes the voltage at which the ozone generator operates. Minimizing the voltage at which an ozone generator operates is of very great importance, for this not only minimizes the high-voltage stress on all components for longer life, but is also safer, minimizes arcing and external corona, and decreases the cost of the electrical power source. Ideally, the discharge occurs at the voltage as low as possible at which the discharge is stable and homogeneous, and the average output power and therefore the amount of ozone generated is controlled by adjusting the voltage rather than the frequency.

It is well known that the wavelength of the ultraviolet radiation depends on the gas used for creating the discharge. For this purpose, the present invention utilizes hydrargyrum (mercury) gas for generating plasma within the quartz tube. The ozone-producing wavelength of the ultraviolet radiation is within the range of about 100 nm to about 128 nm. The ultraviolet light produced in this way, further increases the ozone-generating efficiency within the chamber.

Thus, the present invention enables the use of a smaller, less expensive electrical supply source due to the favorable characteristics of the dielectric barrier between the electrodes obtained upon exposure to the ultraviolet irradiation from the plasma, i.e. the inner electrode.

The use of plasma as an electrode is advantageous also in that ablation on metallic electrode surfaces due to high instantaneous temperatures caused by the current released during electric discharge which occurs in conventional ozone-generating devices is avoided. Thereby, the purity of the ozone generated is higher and the entire device can operate more reliably for a longer time.

The strong beneficial effect occurring in the device according to the present invention is the establishment of resonance between the frequencies of the electric power supply and the electromagnetic frequencies inherent to the plasma. The intense electromagnetic radiation of random noise character is observed at the frequency of plasma oscillation. The plasma noise spectrum is of a complex nature. In practice, it can be compared to the so-called "white noise" which enables to add of a certain amount of noise in an excitable system of the ozone-generating device structure. Eventually, the plasma-generated noise induces oscillations that bring about the resonance with the electrical power supply voltage frequencies. For the above-described resonance to be established, the sine wave of the electric power supply voltage must have the Fourier series of harmonic frequencies. For this purpose, the signal must have a chaotic modulated sine waveform.

Conclusions.

The advantages of "Ozone Generation System" are the following: Is cost and energy-efficient, competitive, ozone generated by barrier and corona discharge and ultraviolet radiation; ozone formation is regulated by airflow, as well as electrical mode of operation; for special requirements, the ozone generator also works on oxygen; the ozone generator is portable, the electric source could be supplied by the vehicle; technology is protected by warranty and post-warranty services; the company is ready to license the technology;

The ozone generation systems of the "**Ozone Georgia**" brand, created by "**Hydrogen Technology**" are implemented in Georgia in many directions, including: wastewater treatment, water bottling plants, product storage facilities, greenhouses, pig farms, wineries - for pitcher disinfection, to deodorize wineries, to replace pesticides and other poisonous chemicals in viticulture, and hazelnut plantations, to disinfect hives in beekeeping, horticulture, silk production, in bread factories, meat factories, lemonade factory, distillery, swimming pools, car swash, bibliotheque, bookstore, barber shop, etc.

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