Influence of the constant electric field on the photon emission characteristics of selected utility cultivars of the Camellia plant

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Abstract. The article presents the research results related to the measurement of the reaction biological substance to extortion, which was a permanent field electric. To identify the degree of reaction of a biological substance, the phenomenon of generating short light pulses was used, which was registered with a photomultiplier tube turned on in an appropriate measurement path. For the research, dried leaves of the Camellia plant were used, which was subjected to the influence of a constant electric field in two voltage combinations, i.e. 1kV and 3kV, and then, using the method of counting single photons, their number was summed in a 1800-second time interval. Significant differences in the number of registered photons were found between the drought subjected to the action of a constant electric field and the drought, where this interaction was not applied. It should be noted that a differentiation was also noted between the dried plants that were subjected to a constant electric field, but with different voltage. Therefore, it is possible, experimentally confirmed, to parameterize the analyzed substance by measuring the total photon emission and identifying selected properties of the substance based on the photon emission characteristics during the measurement.

1. Introduction
The electric field is widely used in various branches of life - in medicine, agriculture and the food industry. The use of electric and magnetic fields can have a positive and negative impact on the functioning of living organisms. It is becoming more and more common due to the development of precise devices generating the fields in question and measuring equipment that allows for precise dosing of a specific field structure onto biological matter. The electric field has long been used in the food industry, e.g. for the so-called cold pasteurization. This method was used for the first time in the case of milk pasteurization, where the discharge duration was the same as in the case of the lightning discharge, and its intensity was 200 kV / cm. The electric field in the conditioning of biological substances can be used directly and indirectly. The direct effect is that the foodstuffs are exposed to the field, which inactivates the microorganisms through irreversible electroporation. Irreversible electroporation is a permanent rupture of the cell wall due to stresses created in the electrical reaction between the charges of the outer and inner cell walls. On the basis of numerous studies, it has been found that the method of direct use of the impulse electric field for the pasteurization of liquids is a very effective method. The
effectiveness of the process depends on the intensity of the electric field, the number of pulses and their duration. After using this method, food products do not lose their taste [1].

The biological systems continuously emit very low light without any external stimuli or additional external phosphors. This phenomenon, commonly referred to as very low photon emission, occurs in virtually all metabolically active systems. Ultra-weak emission of photons is caused by oxidative metabolic reactions in cells. Spontaneous photon emission without special dedicated high-intensity enzyme systems differentiates ultra-low photon emission from ordinary bioluminescence. The application of ultra-low photon emission in food chemistry is mainly based on food quality control. Very low photon emission can serve as a convenient tool to assess the quality of food such as rice, milk and soy sauce, soybeans and bean sprouts [6]. Ultra-low photon emission was also used to assess the quality of products such as fruit, vinegar, olive oil, bread, chocolate and eggs [2-7]. Wherever molecular oxygen and biomacromolecules are present, there will be changes in the intensity of photon emission as a result of oxidative processes. In food products containing living cells capable of active oxidative metabolism and antioxidant defense, the mechanisms of generating ultrafast photon emission are similar to those in living plant and animal tissue [8].

Tea (Camellia sinensis L.) belongs to the Theaceae family. It is the world's oldest non-alcoholic drink containing caffeine and the second most consumed liquid on Earth after water [9,10]. The Chinese were the first to use tea as a medicinal infusion, and later as a drink, which they have been doing for the last 3,000 years. The cultivated taxa consist of three main natural hybrids. The leaf is the main criterion according to which three types of tea are classified. Currently, over 600 cultivars are available worldwide, many of which have unique characteristics such as high caffeine content [10]. The chemical constituents of the tea leaves include polyphenols (catechins and flavonoids), alkaloids (caffeine, theobromine, theophylline), volatile oils, polysaccharides, amino acids, lipids, vitamins (e.g. vitamin C), inorganic elements (e.g. aluminum, fluorine and manganese) [9].

The most popular tea varieties, with the exception of black tea, are white tea, pu erh, rooibos and yerba maté. The buds and young leaves of white tea are harvested shortly before the buds fully open. The leaves are then steamed and dried with minimal processing. For this reason, white tea retains the highest levels of antioxidants and the lowest levels of caffeine than any other C. sinensis tea. Pu erh leaves can be harvested at any time of the year. Its processing is similar to that of black tea. What makes this tea unique is that it is arranged in piles after harvesting, in which it matures from 50 to 100 years [9].

Rooibos is a legume bush native to the Cedarberg Mountains of South Africa's Western Cape, where it is intensively cultivated. After harvesting, the needle-punched leaves and stalks may be bruised and fermented before drying, or dried immediately. During fermentation, the color changes from green to red with the oxidation of polyphenols [11,12]. Yerba maté is a plant native to the subtropical region of South America. The yerba maté processing consists of three steps including a drying process carried out within 24 hours after harvest to inhibit the enzyme activity and reduce the moisture level, partial drying which reduces the moisture content and a further drying step and subsequent grinding. Maté contains many bioactive compounds. The indigenous people of South America were aware of its stimulating properties due to the caffeine content. Today, maté drinks are also recognized as a rich source of phenolic acids, which are responsible for the antioxidant effect [13].

The aim of the research was to determine the possibility of identifying changes in a biological substance based on the characteristics of photon emission. Moreover, the determination of the differentiation in photon emission of dried leaves from four tea varieties that were subjected to the influence of a constant electric field with two voltage values 2kV and 3kV.

2. Materials and methods

The research was carried out on selected utility varieties of the Camellia plant, which were in the form of dried plants. Four varieties of teas were used (Figure 1): White Passion Fruit and Peach, Pu Erha Fitness, Tropical Rooibos and Lemon Yerba maté. 5 g of dried leaves of individual tea varieties were weighed into Petri dishes. Prepared samples were left in the darkroom for 24 hours in order to stabilize them, which is necessary to precisely determine the response to the excitation in the form of a permanent electric field.
The research on the measurement of photon emission was carried out at the Laboratory of Experimental Research Techniques for Raw Materials and Biological Products of the University of Agriculture in Krakow, which has its own procedure for measuring the number of photons accredited by the Polish Center for Accreditation. The methodology of measuring ultra-weak photon emission has been described in other works [2-7]. In the research, the measurement time of photon emission from the analyzed material was extended and the time was divided into smaller measurement intervals, which allowed for plotting the photon emission characteristics as a function of time.

A 30-minute measurement of the photon emission of the control samples and tests subjected to the influence of a constant electric field was performed. For stimulation with a constant electric field, a laboratory stand was used, allowing to generate a constant electric field with a voltage of 0.1 V to 3 kV, and the adjustable distance between the electrodes allows to obtain the intensity from 0.3 kV/cm to 3 kV/cm. Constant electric field parameters were controlled automatically using the original measurement algorithm written with LabView software. The time of exposure to the constant electric field was 30 minutes for each of the two combinations of the applied voltage, ie 2kV and 3kV. After stimulation, a 30-minute thermal light stabilization of the sample was applied, and then the photon emission was measured.
3. Results

Analyzing the number of registered photons in the total counting time of 1800 seconds, a significant variation was observed between the teas selected for the study (Figure 3). In addition, a different trend of the organic substance response in the form of photon emission to the excitation by a constant electric field in the case of YERBY, the number of photons after the application of the electric field decreased from the value of 781 photons (without exposure to the electric field) to 380 photons for this material stimulated with a field voltage of 3kV was found. In the case of other teas, the number of emitted photons increased after the application of a constant electric field. This proves the different reaction of organic matter to the electric field. In the case of teas constituting the control sample, the highest value of photon emission was recorded in the case of yerba tea. A high number of photons was observed for pu-erh and rooibos teas - 208 and 172 photons / 1800 seconds of measurement, respectively. The lowest photon emission was recorded for white tea 107 photons / 1800 seconds of measurement. In the case of stimulation of the samples with a constant electric field with a voltage of 2 kV, an increase in the number of emitted photons from the leaves of white, pu-erh, rooibos and green tea leaves was observed in comparison to the control samples. The highest value was recorded for yerba leaves - 580 photons/1800 measurement seconds. A high number of photons was recorded for rooibos and green tea leaves - 292 and 284 photons / 1800 seconds of measurement, respectively. The lowest photon emission was recorded for white tea 210 photons/1800 seconds of measurement. In the case of the influence on the samples with a constant electric field with a voltage of 3 kV, an increase in photon emission was observed from the samples of pu-erh and green teas, while a decrease in the emission was noted for the other teas compared to samples stimulated with a constant electric field with a voltage of 2 kV. The highest value was recorded for yerba leaves - 380 photons/1800 seconds of measurement. A high number of photons was recorded for green tea leaves and rooibos - 301 and 249 photons/1800 seconds of measurement, respectively. The lowest photon emission was recorded for white tea 158 photons/1800 seconds of measurement.
Figure 3 The photon structure at individual measurement time intervals for each test tea variety. Photons in samples not exposed to the action of a constant electric field were counted. The yerba maté leaves, 781 photons / 1800 seconds of measurement, had the highest photon emission. A high number of photons was observed for pu erh and rooibos teas - 208 and 172 photons / 1800 seconds of measurement, respectively. The lowest photon emission was recorded for white tea 107 photons / 1800 seconds of measurement. Figure 4 shows the photon structure at individual measurement time intervals for each tea variety tested.

Figure 4. Photon emission registered for the control sample of individual tea varieties
After exposure to a constant electric field with a voltage of 2 kV on the leaves of individual tea varieties, the photon emission increased in most samples. Again, the highest number of photons was observed for yerba maté leaves (580 photons / 1800 measurement seconds). In the case of rooibos and pu erh teas, an increase in the number of photons was noted in relation to the control samples, which were respectively 292 and 230 photons / 1800 seconds of measurement. Again, the lowest photon emission was found for white tea leaves 210 photons / 1800 seconds of measurement. Figure 5 shows the photon structure in individual measurement time intervals for each variety of tested tea, under the influence of a constant electric field with a voltage of 2 kV.

Figure 5. Photon emission registered for individual tea varieties after exposure to an electric field with a voltage of 2 kV

Figure 6. Photon emission registered for individual tea varieties after exposure to an electric field with a voltage of 3 kV
The photon emission decreased in each of the samples, as compared to the control samples, after exposure to a constant electric field with a voltage of 3 kV on the leaves of individual tea varieties. The yerba maté leaves 380 photons / 1800 seconds of measurement were again characterized by the highest number of photons. 290 photons / 1800 seconds of measurement were obtained for rooibos tea leaves and 232 photons for pu erh. The lowest number of photons was recorded for white tea leaves 158 photons / 1800 seconds of measurement. Figure 6 shows the photon structure in individual measurement time intervals for each variety of tested tea, under the influence of a constant electric field with a voltage of 3 kV.

4. Conclusion
The interaction of the constant electric field affects the photon emission of biological material in a heterogeneous manner. It may inhibit the emission of photons (yerba) or increase their emission. It should be noted that an increase in emissions was observed for the remaining samples of dried leaves from four teas. The use of various voltage parameters modifies the structure of the photon emission, thus making it possible to identify the degree of interaction. Compared to the control tests, the photon emission of white tea leaves, rooibos and pu erh increased after the application of the constant electric field, while the photon emission of yerba maté leaves decreased regardless of the applied electric field voltage. Comparing both electric field parameters, higher photon emission was obtained in the case of yerba maté, rooibos and white tea samples, while in the case of pu erh it was similar.

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