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Electrotechnological approach for effective storage of fruits and vegetables in farms

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Abstract. It is proposed to use the ozonation method in vegetable and fruit storage facilities of farms that are not equipped with refrigerators. Ozone is a strong disinfecting agent against putrefactive microorganisms. The results of the treatment of apples and carrots with various doses of ozone are given. The effectiveness of this processing method has been verified.

1. Introduction

Development of farms specializing in the production of fruit and vegetable products necessitates an increase in the number of typical vegetables and fruits storage facilities that provide necessary microclimate conditions (temperature, humidity and gas exchange) [1-3, 14-15]. Most farm storage facilities are not equipped with refrigeration units; they mainly use natural or active ventilation. However, this does not always ensure the required storage conditions. As a result, there is a need for additional creation of a certain storage technology, which, at the lowest capital costs, provides the required technological storage conditions. For this purpose, it seems most appropriate to use the method of periodic ozone treatment of stored fruits and vegetables [4-6, 16-18]. Most of the ozone studies have been conducted under refrigerated storage conditions that show high performance. However, storage conditions in rooms where refrigerators are not available are very different. Ozone is one of the strongest existing oxidants effectively disinfecting fruit surface from various putrefactive microorganisms as well as the air in storage space [7-10, 19]. Taking into account the peculiarities of the storage method, regional microclimatic features and the type of stored products, it is necessary to develop a technology for ozone treatment of agricultural products stored in rooms without special refrigeration units [11-13, 19-22].

2. Methods

For experimental studies, a laboratory ozone unit was assembled (Figure 1). The unit consists (1) of electric ozone generator (2), power supply (3), and treatment chamber (4).

An electric ozone generator is a set of flat dielectric (glass) plates 36x16 mm in size, with foil between them. To avoid the edge effect, the foil is spaced 5 mm from the edges of the glass plate. Between two pairs of plates, set at a distance of 3 mm, a quiet electrical charge is generated. The ozone generator has 17 plates in total. Eight of them are active electrode and are grounded. To supply high voltage to the active electrodes, NOM-10 type transformer was used. The voltage on the primary side was monitored by means of a 150-V voltmeter and a 1-A ammeter. The voltage on the secondary side was monitored by means of a C-96 type kilovoltmeter. The air flow rate was measured by using a rotameter RS - 5. The ozone concentration was measured by iodometric titration.

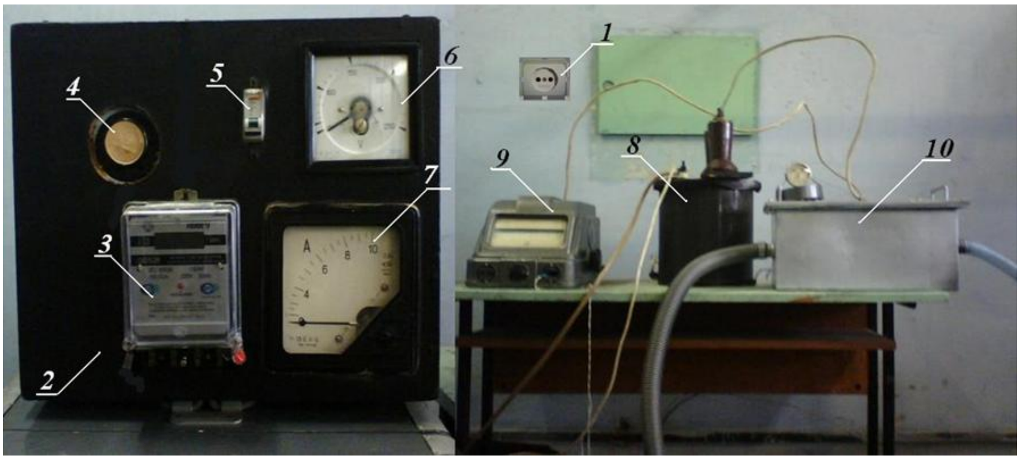

Figure 1. 1 – 220 V power supply; 2 – control unit; 3 – one-phase electricity meter; 4 - autotransformer; 5 – automatic switch; 6 – 230 V voltmeter; 7 – 1 A ammeter; 8 – 10 kV transformer (NOM 10); 9 – 10 kV kilovolt-meter; 10 – ozone generator

The processing of research results was carried out by methods of mathematical statistics. The dynamics of processing was controlled by decreasing fruits and vegetables weight.

3. Results and Discussions

Studies to determine the possibility of using ozone for pretreatment and storage of fruits and vegetables were carried out in laboratory conditions. The model of the laboratory stand is shown in Figure 2.

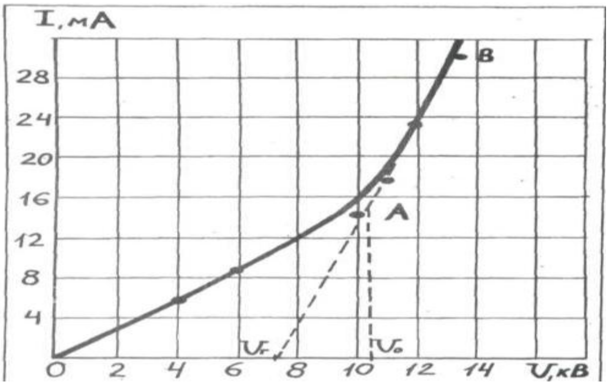

Figure 2. Volt-ampere characteristic of ozone generator

Figure 4 shows a schematic diagram of the storage facility ozonation. The air sucked by the compressor 1 is supplied to the ozone generator 2. The ozone-air mixture is supplied from the generator to the storage Figure 4.

When using ozone, it is often necessary to obtain a given amount of ozonized gas with a certain ozone concentration.

Ozone was obtained by using a laboratory generator that produces it mixed with air. The ozone treatment was carried out at an ozone concentration in the ozone-air mixture of 4 mg/l. The corresponding ozone doses were obtained at treatment lasting 10 minutes, - about 800 mg/m3 = 0.8

g/m3 (processed volume), and with 30 minutes processing 2400 mg/m3 = 2.4 g/m3. Table 4 shows the average values of the mass loss. To determine the repetitions of experiments, setting the confidence probability $\alpha = 0.95$ and the limiting error $\varepsilon = 3\delta$, we found that the number of repetitions should be 3. The results of studies of "Semerenka" apples electrical-ozonation treatment are shown in Fig. 5. Three batches of apples were selected for the study: the first one was processed for 30 minutes, 1 time per week; the second, for 10 min. The third was used as a control group.

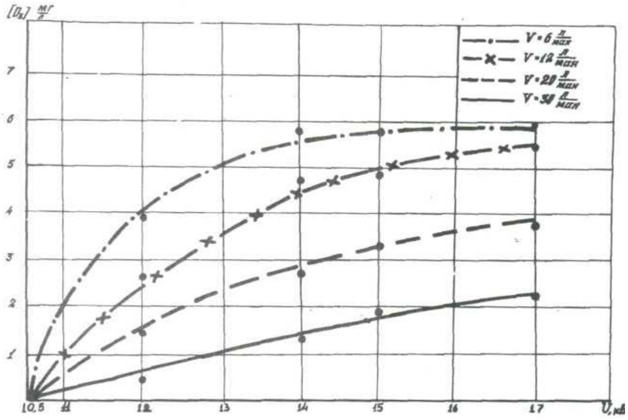

Figure 3. Dependence of the ozone volume on the applied voltage and air flow

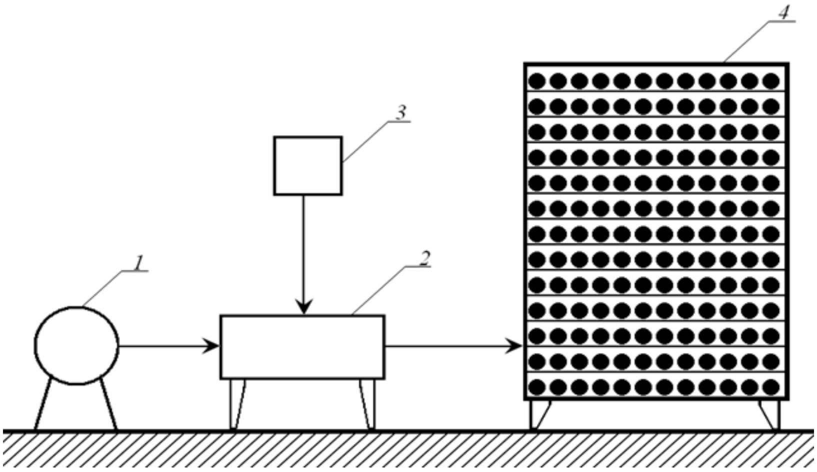

Figure 4. Supplied ozone-air mixture from the generator to the storage: 1 – compressor, 2 – ozone generator, 3 – power supply,4 –treatment chamber

It can be seen from the graph that the weight loss of the batch of apples processed 0.5 hours a week after 30 days of storage was only 7%, while with 10 minutes processing they are equal to 24%. This indicates that at low exposure and all other things being equal, the mass loss increases; respiratory and enzymatic processes are intensified. The control batch from the very beginning of storage showed a high intensity of respiratory and enzymatic processes, where on the 10th day of the storage, the weight loss came to about 10%; and in 19 days, the entire control batch of apples completely deteriorated.

Three identical batches of carrots were selected for the study. One of them was the control one, and the other two were treated with ozone for 10 minutes and 30 min (fig. 6).

It can be seen from the graph that the weight loss of the control samples, starting from the 7th day, increased intensively, and by the 10-day storage period came to about 40%, i.e. practically the carrots are completely spoiled.

Carrot samples at 30 min treatment gave better results than carrot samples at 10 min treatment. During the initial storage period up to 13th day, the curve shows the lowest weight loss. Further weight loss should be attributed to evaporation of moisture rather than respiratory and enzymatic processes.

Table 1. Results of electrical ozonation of apples and carrots

Weight loss study			Average	δ	P±ε
1	2	3	P, %		
Apples (30 min)					
1.8	2.4	2.2	2.1	0.28	2.1±0.84
2.6	3.0	3.0	2.9	0.02	2.9±0.06
3.3	3.1	3.1	3.5	0.07	3.5±0.21
4.4	3.8	3.8	4.1	0.07	4.1±0.21
6.0	5.7	5.7	5.8	0.21	5.8±0.21
7.5	8	8	7.5	0	7.5±0
Apples (10 min)					
1.1	1	1	1	0.07	1±0.21
6.9	8.0	6.9	7.3	0.07	7.3±0.21
12	10.5	10.5	11	0	11±0
16	18	19.5	17.8	0.07	17.8±0.21
20.0	18.5	21	19.8	0.07	19.8±0.21
27	26	24	25.6	0.14	25.6±0.42
Carrot (30 min)					
1.9	2.1	2	2	0	2±0
5.7	6	6.3	6	0	6±0
17.5	15.5	17	16.6	0.14	16.6±0.42
19	18.5	16.5	18	0	18±0
24.5	24.5	25	24.6	0.14	24.6±0.42
32	34	33.5	33.1	0.7	33.1±0.21
Carrot (10 min)					
4.5	4.0	3.8	4.1	0.07	4.1±0.21
11	9.5	9.5	10	0	10±0.21
18.5	17.5	18	18	0	18±0
24	20	24	22.6	0.07	22.6±0.21
29	32	30	30.3	0.014	30.3±0.42
43.5	40	42.5	42	0	42±0

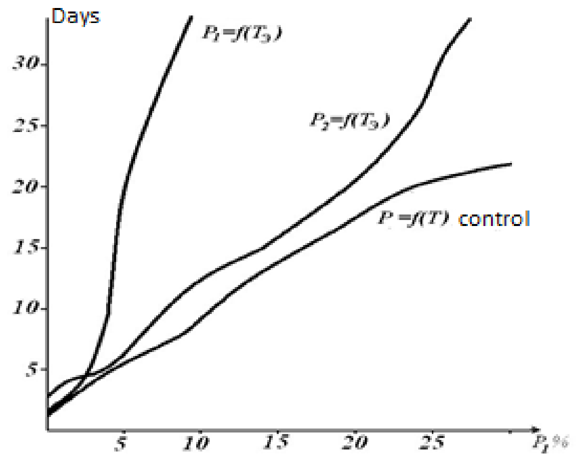

Figure 5. Correlation of the amount of weight loss of ozonized and control apple samples

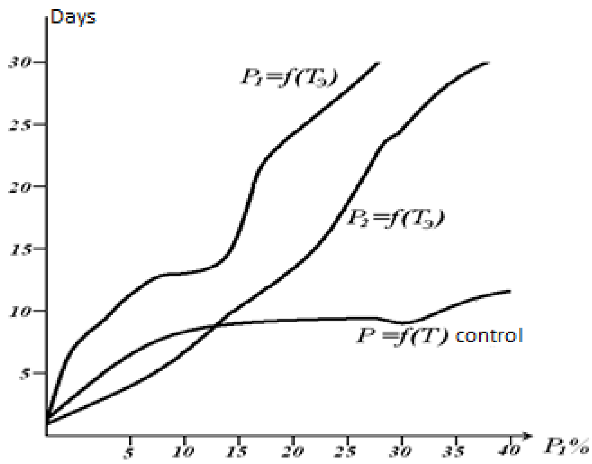

Figure 6. Dependence of the weight loss of ozonized and control carrot samples

4. Conclusions

- In vegetable storages of farms that are not equipped with cooling units, it is proposed to use the ozonation method. A plate type of ozone generator has been developed and studied, which has simple design and reliable operation. The energy characteristics of the ozone generator are studied: the current-voltage characteristic and the dependence of the ozone output on the voltage and air velocity. The performed literary analysis testifies the high oxidizing ability of ozone relative to putrefactive microorganisms on the surface of the fruits, and the excess ozone decays into oxygen.
- Apples and carrots used for storage were treated within 10 minutes (ozone dose 0.8 g/m3) and within 30 minutes (ozone dose 2.4 g/m3). It was found that after 30 minutes of treatment, the loss of storage product mass was 7%; with 10-minute treatment, loss of mass came to 24%, and the control batch in 19 days became unusable. Treatment of carrots with ozone for 30 minutes by the end of the month gives losses of 26-27%, while processing for 10 minutes, observed losses equal to 40%. At the same time, the control batch deteriorated in 12 days. The above results indicate a significant increase in the storage efficiency of fruits due to ozonation.

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