STUDY OF EFFECT OF NEGATIVE AIR IONS ON POTATO LOSS REDUCTION IN LONG TERM STORAGE

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Abstract. The potatoe quality and storage life depend on temperature, relative humidity, gas composition, and air circulation in the storage building. In the event the parameters are violated, the potatoe weight reduces, storage diseases occur, and rot appears. Existing technologies of potato storage in cold ventilated storage buildings are ineffective. They require large expenses on power resources and microclimate systems. Scientists around the world are developing new methods of potato loss reduction during storage. They are examining the application of electric, magnetic, and microwave fields, gamma radiation, chemical inhibitors, etc. The use of gamma radiation and chemical inhibitors is a serious health risk, while other methods are still under-investigated. The article deals with the researches in negative air ion effect on potatoe quality during storage. For the experiments, the following devices were used: a negative air ion generator, an air ion meter, scales, auxiliary equipment. Researches were conducted for three potato cultivars most common in the southern regions of the Russian Federation. During the experiments, the negative air ion concentration effecting on potatoes was 4 500-4 900 ions·cm^{-3}, the exposure time range was from 30 seconds to 15 minutes. The conclusion from the experiments is that the loss of potatoes, exposed to air ions during 120 days of storage, is not more than 8 %. Loss of potatoes not exposed to air ions is up to 39 %. Exposure to positive air ions, on the contrary, increases the potato weight loss compared to the unexposed test patterns.

Keywords: food loss, ionization, negative, ions.

Introduction

Potato production technology may be presented as two blocks: a field work block, which includes growing and harvesting operations, and a storage block. The duration of the first block is 3-4 months depending on the cultivar and the climate in the growing region; the second block (according to the purpose of potato sell-by date) is from 2-3 to 8-11 months, so it is much larger. During the long period, complex physiological-and-biochemical processes take place in the tubers, various pathogenic germs accumulate in the heaps. During the storage, changes occur in the tuber chemistry, due to gaseous constituents of the air and relative humidity, the tubers may be affected by dry and wet rot. Tubers of definite cultivars with a short rest period often start to sprout as early as in December or January, thus, the potato quality decreases and losses increase, usability, as well as seed and sowing characteristics of planting material reduce, and, as a consequence, both planting quality and crop yield decrease. The reduced influence of negative factors on the tubers under storage, provision of high-quality tubers, minimizing of losses are the major tasks of the long-term storage technologies.

Potato storage technology includes the tuber heating, cooling and wetting to avoid undercooling, overheating and evaporation. Proper storage of agricultural products allows to supply people in our country with foodstuff all year round, keep the potatoes good-looking and ensure their high nutritive and taste properties. Moreover, the proper storage of agricultural products is directly related to food safety in our country, therefore, the improvement in storage conditions and reduction of losses in the potato storage buildings is an important and urgent problem.

Many attempts have been made by researchers to investigate the suitability of various storage systems over the years for safe storage of agricultural commodities. Conventional refrigerated room, ventilated cold room, bulk storage facilities, jacketed storage and various types of controlled atmosphere (CA) storage, like Marcellin and Atmolysair, have been used.

Currently, several countries conduct experimental studies aimed at reduction of potato storage loss. Storage loss is mainly caused by the processes, like respiration, sprouting, evaporation of water from the tubers, spread of diseases, changes in the chemical composition and physical properties of the tubers and damage by extreme temperatures. Good storage should prevent excessive loss of moisture, development of rots, and excessive sprout growth. Temperature, humidity, CO_2 and air movement are the most important factors during storage [1-3].

A study of the impact of low-dose irradiation of potatoes found that gamma radiation resulted in the weight loss no more 8 %, as well as gamma radiation, did not inhibit sprouting. However, the build-up effect of gamma radiation is understudied, and the method cannot be widely applied [4-6].

Studies of implementation of low-power electronic beam found that the product exposure on electromagnetic irradiations prevented the potato sprouting during storage, and the nutrient content was not disturbed. However, the method is rather expensive because of the high cost of equipment for producing the electron beam [7-8].

Moreover, the implementation of high-power ionizing radiation showed that in the potato tubers treated in the commercial linear accelerator, the sprouting stopped, the weight loss was not more 4 % after 200 days of storage. However, this method of potato storage is also very expensive [9].

In the process of experimental studies on the treatment of potato tubers with the permanent magnet field it was found that magnetic treatment affects the preservation of the weight of potatoes during storage, at that the polarity and duration of treatment have a significant value. Weight loss of potatoes treated with positive magnetic field of 330-350 mT and time treatment 60-180 s was 4 %. It is anticipated that magnetic fields influence the potato cells, as the result of the effects, potato tubers either lock in moisture, starch and other substances, or lose them quickly due to inner-structure destruction [10-11].

Experimental studies are currently in progress to investigate the implementation of air ionization in storage buildings for potatoes, vegetables, and fruit to increase the quality and shelf life of agricultural products.

Materials and methods

Air ionization is the formation of gas ions in the air during the exposure on the external ionizing agents. Natural and artificial air ionization can be distinguished. Natural air ionization continuously occurs in nature due to electric charges in the air, UV and corpuscular sun rays, radiological agents, massive water spraying.

For artificial air ionization, special devices known as air-ionizers are necessary. Air ions can be separated from the water neutral molecules by dispersion of liquids and solids called ionization due to balloelectric effect; frictional electrification called triboelectrification; chemical reactions or chemical ionization; heating to high temperatures or thermal ionization; UV, X-ray and gamma radiation, as well as a flux of particles of radioactive radiation and artificially obtained fluxes including high-energy electrons and ions; thermo-electronic emission and photo-electronic emission; in response to electrical discharges in the air.

The goal of the experiment was to identify: the specific nature of positive and negative electron effect on potato tubers; the optimal parameters of air ion impact on the potato weight loss; the dynamics of changes occurred in the treated potato tubers in comparison with the untreated ones. During the experiment, standard testing methods were used: multi-factor experiment, statistical analysis, assessment of the adequacy. The measuring devices used in the experiment have certificates of the Russian Federation. The treatment efficiency was estimated by the residual weight of tubers.

The measuring devices used in the experiment: electronic scales, voltmeter, ampere-meter, stopwatch, concentration meter *Сапфир – 3M (SAPPHIRE – 3M)* for positive and negative air ions (Fig. 1), pyrometer for measuring temperature, humidity sensors, microscope.

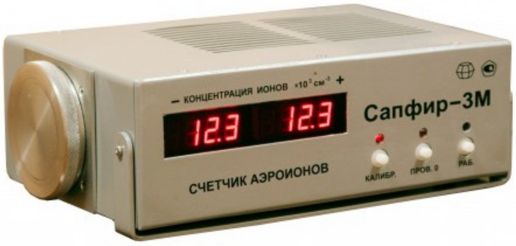

Fig. 1. **Exterior of the measuring device for positive and negative air ions *Сапфир – 3M (SAPPHIRE – 3M)***

For the experimental studies, the *Aurora* variety was used. During the experiment, the ИОН air ionizer was applied, which produced negative air ions with concentration up to 5 000 ions·cm^{-3} (Fig. 2).

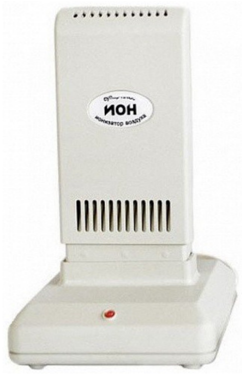

Fig. 2. **ИОН (ION) air ionizer**

The tuber treatment with negative air ions was conducted in the following way: 1 kg of potatoes were placed into a closed box, and a generator of negative air ions was turned on, the running time of the generator was from 1 min to 15 min for different periods of treatment, the air ion concentration was within the range of 4 500-5 000 ions·cm^{-3}. The variants with positive air ions were treated in a similar way. Then the potatoes were laid for storage in packages for 20 days at a constant air temperature of 25 ºC and 70 % humidity. In 20 days of storage, the measurements were made related to the weight of the tested potatoes, and the weight loss was defined as a percentage of the initial value at the beginning of the experiment.

The loss of potato weight at the end of the experiment was determined with the formula (1):

$$\Delta = 100 - \left(\frac{m_{END}}{m_{BEG}} \cdot 100 \right), \% \tag{1}$$

where m_{END} – weight of tubers at the end of the experiment, kg;
m_{BEG} – weight of tubers at the beginning of the experiment, kg.

Also in the course of the experiment, the sprouting in potatoes was recorded, and the length of sprouts was measured. For the statistical analysis the STATISTICA 12 program was used.

Results and discussion

The conclusion from the experiment is that the control has the biggest weight loss (39 %), however, the increase in the period of tuber treatment with negative air ions does not decrease the weight loss, which was expected during the experiment, but it is unstable. The optimal mode of treatment is a 5-minute or a similar period, so this mode needs further investigations (Table 1).

The investigation of the impact of positive air ions on potato tubers proves that the entire range of tubers treated for 1-15 min gives bigger weight loss than the untreated control and reaches 65 %.

Table 1

Impact of negative and positive air ions on potato (*Aurora* variety) weight loss

Charge and concentration of ions, ions·cm^{-3}	Processing time, minutes	Weight loss, %
sign "-" 4 500-5 000	1	26
	5	23
	10	32
	15	30
sign " + " 4 500-5 000	1	52
	5	44
	10	59
	15	65
Untreated control	0	39

Also, the changes occur in the appearance of the potatoes treated with negative and positive air ions (Fig. 3-8).

Fig. 3. **Appearance of the potato tubers: untreated control, at the beginning of the experiment**

Fig. 4. **Appearance of the potato tubers: untreated control, at the end of the experiment**

Fig. 5. **Appearance of the potato tubers: treatment with positive air ions, at the beginning of the experiment**

Fig. 6. **Appearance of the potato tubers: treatment with positive air ions, at the end of the experiment (the largest loss is 65 %)**

Fig. 7. **Appearance of the potato tubers: treatment with negative air ions, at the beginning of the experiment**

Fig. 8. **Appearance of the potato tubers: treatment with negative air ions, at the end of the experiment (the largest loss is 23 %)**

It was stated in the course of the experiment that the weight loss of the potatoes stored in the building with ionized air reduces at 40 %, the harmful bacteria activity decreases, the rot is localized, the protecting crust on the damaged and cut off tubers forms much faster than on the untreated control, repair of the damaged stuff occurs.

Conclusions

1. With the negative air ion concentration of 4 500-5 000 ions·cm^{-3} and 5 minute period of treatment, the maximum loss in potatoes was 23 %.
2. Increase in the period of treatment with negative air ions does not decrease the weight loss, it is unstable.
3. For the potatoes treated with positive air ions, the loss for all treated variants was bigger than for the untreated variant (44-65 %, untreated variant – 39 %).

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