Medicon Agriculture & Environmental Sciences
Volume 4 Issue 3 March 2023
Research Article

Study of the Influence of Ionized Air on Grapes

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Received: February 12, 2023; **Published:** March 02, 2023

DOI: 10.55162/MCAES.04.100

Abstract

The article presents the results of studying the process of storage of grapes in a fruit storage, identifies the main factors affecting the quality of storage of the product. The mechanism of the effect of ionized air on the stored product is considered and fruit storage modes are determined. The results of studies show the possibilities of determining the operating modes of ionization of fruit storage air. For Toifi Pink variety of grapes, the storage temperature is (0-1)°C, and the relative humidity is 90%, the volume concentration of air ions is $n=0.5\text{-}1.0\cdot10^{13}$ ion·m^3, and the duration of ionization is 2 and 4 hours once or twice a week. After storage, the marketable product amounted to 90.6-92.5% and waste - to 7.5-9.4%.

Keywords: Storage of grapes; modes of electro technological processing during long-term storage of grapes; the main factors; the volume concentration of ions and the duration of processing of the product

Introduction

Studies on the influence of factors of the artificial microclimate of fruit storage on the preservation of grapes were conducted in Bulgaria, Moldova, Georgia, Italy, Slovakia, and many other countries, including the Republic of Uzbekistan [1-6]. The technology of short-term and long-term storage of grapes is developed taking into account the biological characteristics of the stored product. During long-term storage, bunches of grapes are in direct contact with air. The released moisture and heat must be freely removed from the surface of the product and the loss of nutrients must be minimal. The effect of exposure to ionized air is to slow down the metabolism of grapes with the environment since the metabolism proceeds in parallel with the exchange of ions. To do this, ionized air must be uniformly distributed in the storage facility, as a result of which the stored product is completely covered with an ionized layerж breathing and moisture loss of the product slows down to the minimum, and its quality is maintained for a long time [7-9].

Research Methodology

The studies were conducted in the holding rooms of the fruit storage with a capacity of 10 and 30 tons of grapes. For each option, a room with a volume of 10 m^3 was allocated, where 50 kg of the product was placed. The experiments were performed with 5 times repetition [10, 11].

Electric ionizers were installed in the experimental rooms and the air was periodically ionized according to the plan of experimental studies. The grapes were put into storage in wooden boxes №1, in one layer at an angle of 50-60°. In the experiments, grapes of the Toifi Pink variety, grown in the Syrdarya and Tashkent regions, were used. This grape variety ripens in September-October and is well

preserved [12-14]. The grapes are harvested by hand, and on the same day they are pre-cooled and put into long-term storage.

According to the plan, there are 8 experimental and 2 check (control) options. Each option contains 500 kg of grapes. The microclimate of the facilities is cooled. The air temperature is 0-10°C and the relative humidity is 90%. The intensity of air ionization is determined based on the complete suppression of pathogens that infect grapes during long-term storage. The value of the volume concentration of air ions was measured with an aspiration ion counter operating on the principle of discharge [15, 16]. Commodity-consumer and chemical-biological parameters were determined according to the generally accepted method [17].

During long-term storage, grapes are mainly affected by bacteria *Pensillium glaucum* and *Botrgtis cinerea* [18]. Therefore, under laboratory conditions, we studied the degree of influence of air ions on the vital activity (survival) of bacteria *Pensillium glaucum* and *Botrgtis cinerea*; the results make it possible to determine the modes of air ionization of fruit storage facilities during long-term storage of grapes. Microbiological analyses were conducted together with the Department of Biology of the Tashkent State Agrarian University.

Experiments show that the growth of bacteria *Pensillium glaucum* and Botrgtis cinerea slows down significantly when the number of ions in $1m^3$ of air is 10^{13}. When the room air is ionized with a volume concentration of 10^{13} ions/m^3 for 1.5-2 hours, the vital activity of bacteria *Pensillium glaucum* and *Botrgtis cinerea* is completely suppressed (Fig.1) [19, 20].

The product after processing was stored for 20 days under cooling conditions. The air temperature (0-1°C), the relative air humidity (90%), and the volume concentration of air ions (10^{12}-10^{13} ion m^{-3}) were controlled. Samples of bacteria *Pensillium glaucum* and *Botrgtis cinerea* were placed in rooms with a volume of 0.5 m^3 and processed according to the plan of experimental studies.

Thus, in order to completely suppress bacteria that infect grapes during storage, a volume concentration of air ions of 10^{12}-10^{13} ion m^{-3} is required, and the processing time is 2-4 hours [20]. These processing modes also reduce the loss of nutrients and moisture content.

According to the results obtained, the following options for experiments on the long-term storage of grapes were set:

- In cooled storage conditions, the volume concentration of air ions is 10^{13} ion m^{-3} of negative polarity, the product was processed for 2 and 4 hours twice a week (options 1,2);
- In cooled storage conditions, the volume concentration of air ions is 10^{12} ion m^{-3} of negative polarity, the product was processed for 2 and 4 hours twice a week (options 3, 4);
- Check (control) options (options 5, 6).

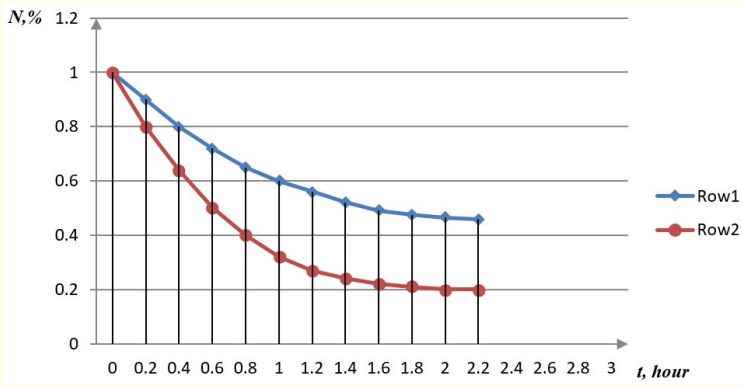

Figure 1: Graph of dependence (life activity) of the survival of bacteria *Pensillium glaucum* and *Botrgtis cinerea* on the dosage of the product treatment: 1-10^{12} ion/m^3; 2-10^{13} ion/m^3.

Before storage, the air in the room was treated with maximum intensity (volume concentration of air ions 10^{13} ion m^{-3}) for 8 hours in order to sterilize the internal walls and equipment of fruit storage. After that, the product was placed in the holding room. For each option, 50 boxes of grapes were laid, 5 rows, 10 boxes on each row. A total of 3 tons of grapes were laid. During storage, the product was periodically examined, and the marketable and organoleptic characteristics of the product were determined. Weight loss was evaluated by weighing the product.

The uniformity of air ionization was controlled during processing. Air parameters were measured along the centerline of the storage room at a height level from the floor of 0.5; 1.0; 1.5 m. The air temperature fluctuated within (0.4-0.6)°C. The long-term operation of the air ionizer did not affect the performance of the storage microclimate. The ionization modes were controlled by changing the voltage of the discharge electrodes. At a voltage of discharge electrodes (4-5) kV, the volume concentration of air ions was in the range of 10^{12}-10^{13} ion m^{-3} [21, 22].

In determining the weight of the main factors, questionnaires from a survey of specialists in the sphere of long-term grape storage were used. Summarizing the results of the questionnaire survey, the weight series of the main factors was determined (Table 1).

S. No	*Name of factors*	*Designation*	*Unit of measure*	*Interval of changes*	*Weight of factors*
1	Air temperature	t	^{0}C	-1-4	10
2	Relative humidity	w	%	85-92	10
3	Volume concentration of air ions	n	ion/m^3	10^{12}-10^{13}	8
4	Ionization duration	τ	h	2-6	6
5	Air velocity in storage room	v	м/s	0,1	2
6	The chemical composition of the air	O_2, CO_2, N_2	%		5
7	Room illumination	E	lux		0
8	Cleaning quality	+			5
9	Agrotechnics of cultivation	+			3
10	Soil condition	+			2
11	Transportation conditions	+			5

Table 1: Important factors of the storage process.

Analyzing the results of the table, three main factors were chosen; for the selected factors, the limit of change and the limit of the study were determined. For each factor, the limit and step of the change were set.

S. No	*Name of factors*	*Designation*	*Unit of measure*	*Interval of changes*	*The limit of the study*
1	Volume concentration of air ions	X_1-n	ion/m^3	10^{11}-10^{14}	10^{12}-10^{13}
2	The duration of the ionizer operation	X_2- τ	h	1-8	2-4
3	Air temperature	X_3-t	^{0}C	-2-10	0-1

Table 2: Table of selected main factors.

Thus, the main factor of the process is the volume concentration of air ions [23-25]. During long-term storage of grapes, the volume concentration of air ions was maintained within 10^{12}-10^{13} ion m^3 and the duration of the process was 2-4 hours, this mode is sufficient for the complete destroying pathogenic micro-organisms in the fruit storage (Fig.1). The research was conducted for three years. In preliminary studies, Toifi Pink variety grapes were stored under optimal conditions from September 30 to January 15 and positive results were obtained.

Electroionizers were installed in the fittings of the ventilation system on top of the product stacks. The ionizer electrodes were designed with small discharge distances (20–30 mm), which makes it possible to obtain sufficient ionization intensity at low voltages (4-6 kV), i.e. while the volume concentration of ions is within 10^{12}-10^{13} ion m^3. To measure the volume concentration of air ions, the air passed through the measuring capacitor of the ion counter. After a certain time, the measuring capacitor was discharged, and the volume concentration of air ions was determined from the discharge current. The research results are presented in tabular form (Table 4).

Research Results

The grapes were put into storage according to the scheme of experimental studies. All parameters were controlled automatically. The product was periodically examined and physical and chemical parameters were determined. In particular, the amount of dry substances, total sugars, titrate acid, pectins, and vitamins were determined.

S. No	*Options*	*Dry substances*	*Total sugars*	*Titrate acid*	*Pectin substances*	*Vitamins mg, %*
1	Before storage	21.13	18.7	0.47	1.18	1.9
2	After storage: experience	20.92	18.4	1.05	0.79	0.95
		20.89	18.51	1.01	0.86	0.98
		20.88	18.39	1.025	0.77	0.94
3	After storage: check	20.3	17.9	1.1	0.56	0.93

Table 3: The results of studies on the storage of Toifi variety grapes for three months.

Below are the results of a three-year study on the storage of Toifi Pink grapes in cooled conditions of the fruit storage facilities.

S. No	*Options*	*Ionization modes*		*Storage modes*		*Yield of products after storage, %*		
		$X_1 10^{13}$ ion·m^{-3}	X_2, h	X_3, °C	X_4, %	*Standard*	*Waste*	*Weight Loss*
1	With negatively charged ions	1.0	2	0	90	90.6	9.4	4.15
2		0.1	2	0	90	86.9	13.1	3.9
3		1.0	4	0	90	92.5	7.5	4.3
4		0.1	4	0	90	89.4	10.6	3.9
5	check	-	-	10	75	62.8	37.2	7.02
6		-	-	10	75	64.5	35.5	6.1
7		-	-	0	90	73.2	26.8	4.05
8		-	-	0	90	70.7	29.3	3.98

Table 4: The results of a three-year study on the storage of Toifi grapes.

Studies show that the best results of long-term storage are obtained when the product is treated with negative ions under cooling conditions. Weight loss is less and in the range of 3.9-4.3%, while in check (control) options this figure is 7%. The best result was obtained for options 1 and 3, while the volume concentration of air ions was within 10^{13} ion·m^{-3}, the duration of ionization was 2 and 4 hours, the air temperature was 0°C and the relative humidity was 90%; after storage, the marketable product amounted to 90, 6-92.5% and waste - to 7.5-9.4%. The research results can be used for long-term storage of other fruits (apples, quince, pears, etc.).

Conclusions

1. The efficiency of product storage in ionized air depends on the volume concentration of air ions and the duration of air ionization.
2. For Toifi Pink variety of grapes, the storage temperature is (0-1)°C, and the relative humidity is 90%, the volume concentration of air ions is n = 0.5-1.0·10^{13} ion·m^3, and the duration of ionization is 2 and 4 hours once or twice a week. After storage, the marketable product amounted to 90.6-92.5% and waste - to 7.5-9.4%.
3. It is also appropriate to treat internal walls, equipment. and implements with ionized air before storing the product since this eliminates the need for chemical treatment.

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