RESEARCH ON THE INFLUENCE OF CARBON DIOXIDE-RICH ATMOSPHERE OF SHORT TERM STORAGE OF GRAPES

CERCETĂRI PRIVIND INFLUENȚA ATMOSFEREI BOGATE ÎN DIOXID DE CARBON ASUPRA PĂSTRĂRII DE SCURTĂ DURATĂ A STRUGURILOR

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Abstract. *The research aimed at determining the optimal concentration of carbon dioxide in the short-term storage in correlation with decrease temperature to approx. 20 C. At the same time we intended to see the effect of carbon dioxide on the metabolic activity and on pathogens. After conducting experiments we established that all modified atmospheres with carbon dioxide have reduced losses. The high content in carbon dioxide of the storage environment exerts a direct influence of inhibition on developing pathogens and carbon dioxide concentrations do not produce in fruits the essential chemical transformation that can influence their quality in a negative way. The total losses were minimal for the variant when it has been used CO_2 concentration of 20%, both at hot and at cold.*
Key words: *carbon dioxide, grapes, storage*

Rezumat. *Cercetările au urmărit determinarea concentrației optime de dioxid de carbon necesară păstrării de scurtă durată în corelare cu scăderea temperaturii la cca. 20^0 C. Totodată s-a urmărit efectul dioxidului de carbon asupra activitătii metabolice şi asupra agenților patogeni. In urma efectuării experimentărilor s-a stabilit că în variantele cu atmosferă modificată cu dioxid de carbon se reduc pierderile. Conținutul ridicat în dioxiod de carbon al mediului de păstrare exercită o influență directă de inhibare a dezvoltării agenților patogeni, iar concentrațiile de dioxid de carbon nu produc în fructe transformări chimice esențiale care să le influențeze negativ calitatea. Pierderile totale au fost minime pentru varianta în care s-a utilizat concentrația de 20% CO_2, atât la cald cât şi la frig.*
Cuvinte cheie: *dioxid de cabon, struguri, păstrare*

INTRODUCTION

Using the gas with inhibitory effect on the metabolic activity of the product and pathogens during transportation has been studied for many researchers. Both, the low O_2 level and high CO_2 level of concentrations reduce the breathing rate.

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Ever since 1963, based on laboratory tests, are recommended the transportation og strawberries, raspberries and cherries in modified atmosphere with carbon dioxide in concentration of 20-25% (Smith and Skog,1992).

There have been numerous efforts to create the necessary gas mixture around the fruits and to establish the mathematical equations for calculating the concentration of O_2 and CO_2 from the microatmosphere in a polymeric film for packaging (Jurin and Karel, 1963). It were used computerized methods to solve the mathematical equations for calculating the gas concentration in the packaging system for transportation (Henig and Gilbert, 1975; Rohrbach and all, 1984).

All the abovementioned models require the knowledge of the O_2 consumption rate and CO_2 evolution concerning the respiration rate, which are based on O_2 and CO_2 composition from medium.

In 1984, several researchers tested pre-cooling with liquid carbon dioxide for blackberries and grapes packed in conventional and unconventional packaging materials. They found that dehydration of fruits was not significant during pre-cooling and was reduced to half in conventional packaging material's using and for the unconventional material's the reduction was 5-25% more.

MATERIAL AND METHOD

Through the developed experiments it was mainly aimed to establish the optimal concentration of carbon dioxide which contributes to maintain the quality of grapes during transportation, by organizing experiments both "at warm" (ambiental temperature in working space - approx. 25^0 C) and" at cold - approx. 20^0 C).

There was used grapes from Afuz-Ali, Muscat d'Adda şi Alphonse Lavalée varieties.

Apparature, devices and installations:

- hermetically sealed containers for keeping the concentration of experimental carbon dioxide
- TBV – 2000 climate chamber
- INFRALIT gas analyzer equipped with (measuring range 0-50% CO_2)
- CARLO ERBA gas chromatograph for measuring the concentration in ethylene
- laboratory equipment

The research method consisted in an analytical and comparative analysis regarding the grapes's behavior in normal and modified atmosphere with carbon dioxide, to "cold " (in climate chamber) and "warm" (in laboratory).

Were developed the following variants:

V_{01} – Witness- environment in laboratory atmosphere (approx. 25^0 C)
V_{02} – Witness- environment in climate chamber atmosphere (approx. 2^0 C)
M_1 – Normal atmosphere in laboratory container
M_2 – Normal atmosphere in container from climate chamber
V_1 – Modified atmosphere with 10% concentration of CO_2 in laboratory
V_2 – Modified atmosphere with 20% concentration of CO_2 in laboratory
V_3 – Modified atmosphere with 30% concentration of CO_2 in laboratory
V_4 – Modified atmosphere with 10% concentration of CO_2 in climate chamber
V_5 – Modified atmosphere with 20% concentration of CO_2 in climate chamber

V_6 – Modified atmosphere with 30% concentration of CO_2 in climate chamber

Were made observations and determinations in dynamics regarding:

- fruit aspect and organoleptic analysis
- firmness
- weight loss
- evolution of CO_2 concentration related with temperature and time
- evolution of ethylene concentration
- chemical composition
- fruit's health

For each variant were done at least 3 measurements. Samples ,,at warm" were removed after 3 days and those ,,at cold" after 6 days. Measuring the concentration was made after 3 days in both situation and after 6 days just for ,,at cold ".

RESULTS AND DISCUSSIONS

The evolution of total losses in the case of grapes, as is shown in Table 1, it is different from the other studied fruits. The total losses are much smaller and present the minimum value in the case of the variants with 20% CO_2, both ,,at warm" and ,,at cold". Unlike the other fruits, losses (depreciation) by softening are non-existent. Samples from "at warm" had presented mold attack but at low intensity, especially on the Afuz-Ali variety's cob/axis. In case ,,at cold "was not found mold attack in any variant.

Table 1

Weight losses achieved in experiments regarding the behavior of grapes from Afuz-Ali variety in modified atmospheres with carbon dioxide ,, at warm " (after 3 days and a temperature of approx. 16^0 C) and ,,at cold" (after 6 days and a temperature of approx. 2^0 C)

Variant	Symbol	Total losses		of which:					
				Weight losses		Softening losses		Mold attack losses	
		warm	cold	warm	cold	warm	cold	warm	cold
Witness-environment	V_{01}	7,09	-	6,66	-	-	-	0,43	-
	V_{02}	-	3,8	-	3,8	-	-	-	-
Normal atmosphere in container	M_1	3,44	-	0,6	-		-	2,84	-
	M_2	-	0,71	-	0,71	-	-	-	-
Modified atmosphere with 10% CO_2	V_1	3,42	-	0,67	-	-	-	2,75	-
	V_4	-	0,48	-	0,48	-	-	-	-
Modified atmosphere with 20% CO_2	V_2	1,74	-	0,66	-	-	-	1,08	-
	V_5	-	0,13	-	0,13	-	-	-	-
Modified atmosphere with 30% CO_2	V_3	3,86	-	0,43	-	-	-	3,33	-
	V_6		0,73	-	0,73	-	-	-	-

The carbon dioxide has reduced the losses in situation with 20% CO_2 by 4 times ,,at warm" comparing with witness case and 29 times ,,at cold".

The evolution of CO_2's concentration at grapes shows a difference comparing with the other studied fruits. „At warm" the concentration in carbon dioxide increases more slowly as in the other fruits, while "at cold„ it is produced a decrease of concentration (Table 2).

Table 2

Evolution of CO_2's concentration in grapes

Symbol	Initial CO_2's concentration	Warm (approx. 16^0C):			Cold (2^0 C) :				
		3 days	6 days	9 days	3 days	6 days	9 days	12 days	15 days
M_1	-	6,5	12,5	16,7	-	-	-	-	-
M_2		-	-		3,1	2,5	3,1	3,8	
V_1	10	17	28,5	38	-	-	-	-	-
V_2	20	31	39,5	47,5	-	-	-	-	-
V_3	30	34	40,5	50	-	-	-	-	-
V_4	10	-	-	-	8,2	7,3	8,1	9,3	-
V_5	20	-	-	-	11,1	10,0	10,7	11,7	-
V_6	30	-	-	-	14,3	13,0	13,8	14,0	-

After a longer storage of grapes was repeated the experience (Table 3 and 4), the conclusion being that the concentration decreases to a minimum value (in the 6^{th} day) and after that increases slightly. The grapes have not released ethylene.

Table 3

Analytical changes produced in grapes during the experiences regarding their behavior in modified atmospheres with carbon dioxide after 9 days at approx. 16^0 C temperature

Symbol	Dry substance %			Total sugars %			Acidity %		
	prim.	end	dif.	prim.	end	dif.	prim.	end	dif.
V_{01}-white	19,9	18,1	-1,8	186,3	167,2	-19,1	0,61	0,58	-0,03
V_{01} -red	20,9	11,9	-9	196,9	101,4	-95,5	0,61	0,63	0,02
M_1- white	19,9	17,4	-2,5	186,3	159,7	-26,6	0,61	0,59	-0,02
M_1 - red	20,9	19,1	-1,8	196,9	177,8	-19,1	0,61	0,62	0,01
V_1 - white	19,9	16,6	-3,3	186,3	151,2	-35,1	0,61	0,54	-0,07
V_1 - red	20,9	13,1	-7,8	196,9	114,1	-82,8	0,61	0,58	-0,03
V_2 - white	19,9	17,6	-2,3	186,3	161,9	-24,4	0,61	0,49	-0,12
V_2 - red	20,9	13,3	-7,6	196,9	116,3	-80,6	0,61	0,62	0,01
V_3 - white	19,9	16,1	-3,8	186,3	147,0	-39,3	0,61	0,65	0,04
V_3 - red	20,9	15,3	-5,6	196,9	137,4	-59,5	0,61	0,53	-0,08

From Tables 3 and 4 result that in grapes stored for 9 days „at warm" and 12 days „at cold" had produced no essential chemical transformation able to improve its quality. The significant changes were noticed to sugars, between 62.6% for witness variant and 1.1 for the variant with 20% CO_2 „at cold" and

between 95.5% for witness variant and 19.1 for the witness variant in container „at warm".

It doesn't change the taste unlike the other fruits where occurred flavor anomalies due to carbon dioxide impregnation.

Phytosanitary condition of grapes stored in modified atmosphere is reflected in Table 5.

Table 4

Analytical changes produced in grapes during the experiences regarding their behavior in modified atmospheres with carbon dioxide after 12 days (2^0 C)

Symbol	Dry substance %			Total sugars %			Acidity %		
	prim.	end	dif.	prim.	end	dif.	prim.	end	dif.
V_{02}-white	19,9	14,0	-5,9	186,3	123,7	-62,6	0,61	0,59	-0,02
V_{02} - red	20,9	19,5	-1,4	196,9	182,0	-14,9	0,61	0,62	0,01
M_2- white	19,9	20	0,1	186,3	187,4	1,1	0,61	0,53	-0,08
M_2 - red	20,9	20,5	-0,4	196,9	192,7	-4,2	0,61	0,54	-0,07
V_4 - white	19,9	15,7	-4,2	186,3	141,7	-44,6	0,61	0,48	-0,13
V_4 - red	20,9	20,4	-0,5	196,9	191,6	-5,3	0,61	0,57	-0,04
V_5 - white	19,9	18,6	-1,3	186,3	172,5	-13,8	0,61	0,40	-0,21
V_5 - red	20,9	21	0,1	196,9	195,8	-1,1	0,61	0,56	-0,05
V_6 - white	19,9	21	1,1	186,3	174,6	-11,7	0,61	0,43	-0,18
V_6 - red	20,9	22	1,1	196,9	185,2	-11,7	0,61	0,53	-0,08

Table 5

Phytosanitary condition of grapes in mofified atmosphere with carbon dioxide

Grapes affected by pathogens after 9 days of storage "at warm"						
Variety	**Initial**	**Normal atmosphere**	**Normal atmosphere in container**	**10% CO_2**	**20% CO_2**	**30% CO_2**
Muscat d'Adda	2,12 *Botrytis*		21,5 *Botrytis*	0		
Afuz-Ali	4,16 *Botrytis*		11,7 *Botrytis*			
after 12 days „at cold"						
Muscat d'Adda	2,12 *Botrytis*		14,28 *Botrytis Penicillium*	18,18 *Botrytis*	17,5 *Botrytis*	30,7 *Botrytis*
Afuz-Ali	4,16 *Botrytis*	14,2 *Botrytis Penicillium*	11,4 *Botrytis*	10,0 *Botrytis*		13,5 *Botrytis*

It was noticed a *Botrytis* attack on all witness samples from container, after 5 days of exicator keeping in the relative humidity conditions (approx. 90%) and laboratory temperature (approx. 160° C). The Muscat d 'Adda variety was attaked by *Botrytis* in all samples with modified atmosphere „at cold". *Botrytis* appeared „at warm" on the cob/ axis of bunches in atmospheres with 20% and 30% CO_2. In 30% CO_2 atmosphere „at cold" it was noticed the occurrence of *Rhizopus mycelium* on Afuz-Ali variety.

CONCLUSIONS

Laboratory tests on grapes were made to create the possibility of substantiating their behavior in different atmospheres with carbon dioxide (10% CO_2, 20% $CO_2$and 30% CO_2).

The purpose of these measurements was to establish the usefulness and optimal percentage of carbon dioxide in modified atmospheres for transportation of fresh fruits and storage on short term of the fruits.

Conclusions resulting from experience:

- all modified atmospheres with carbon dioxide reduce losses;
- CO_2 concentrations ,,at cold" decrease to a minimum in the 6^{th} day and then increase very slightly, but without reaching the initial value in the studied period;
- CO_2 concentration from fruit's respiration decreases with increasing the CO_2 percent initial introduced in modified atmosphere;
- grapes have not released ethylene;
- high content of CO_2 atmospheres exerts a direct influence in inhibiting the evolution of pathogenic fungi existing on the fruit's surface;
- CO_2 concentrations do not produce essential chemical transformation in fruits which can negatively influence their quality;
- with increasing of CO_2 concentration do not appear flavor anomalys at grapes .

Considering the obtained results in the laboratory determinations, the optimal conditions for the transportation of grapes are considered to be: low temperature of approx. 20^0 C associated with a controlled atmosphere between 10% and 20% of CO_2 (for 2 or 4 days).

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