III International Scientific Conference "**Sustainable and efficient use of energy, water and natural resources – SEWAN-2021**"

Biological method of gaseous media formation during cold storage of fruits using track membranes

Authors: Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

Affiliations: Faculty of Biotechnologies (BioTech), ITMO University

Saint-Petersburg, April 19-24, 2021

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Research Objective: to investigate and substantiate the formation of the gas composition depending on the respiratory rate of fruits and the selectivity of track membranes during cold storage of apples of autumn varieties

Objects of research: apples of autumn varieties:

- *Grushovka Yudicheva*
- *Kordonovka*
- *Pepin Shafrannyi*

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Collaborative development:

ITMO UNIVERSITY

Pavlovsk Experimental Station of Vavilov Institute of Plant Industry

ВНИИСК

Federal State Unitary Enterprise «S.V. Lebedev Institute of synthetic rubber»

Ioffe Physical-Technical Institute of the Russian Academy of Sciences

Biological method of gaseous media formation during cold storage of fruits using track membranes

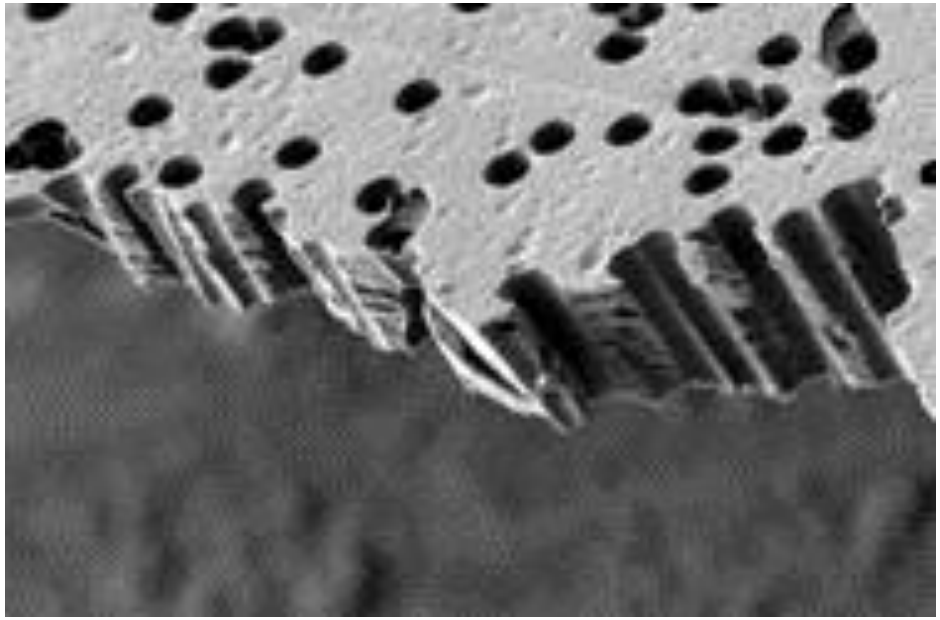
Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

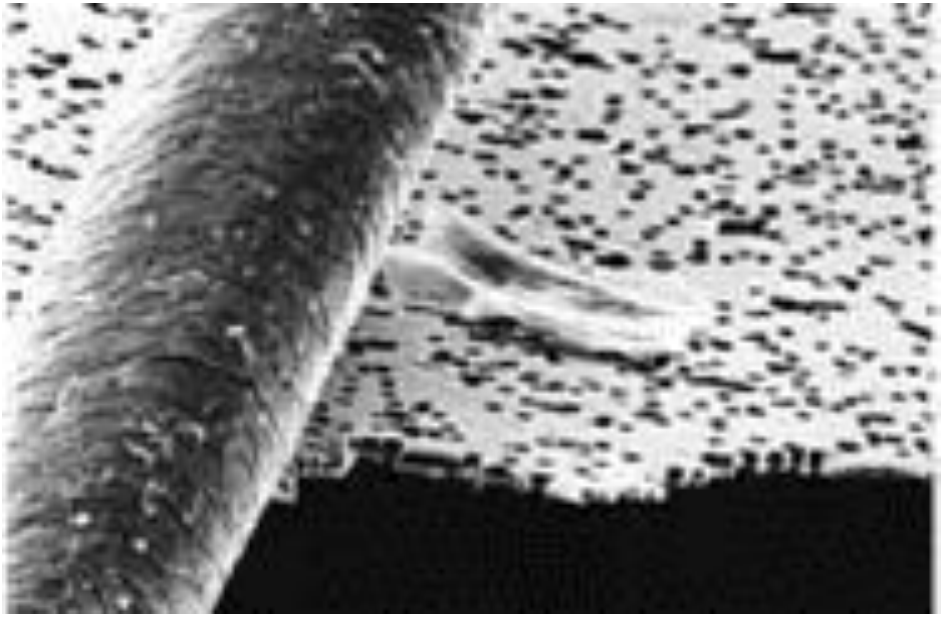
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Gas-selective membrane material with a track membranes substrate based on polyethylene terephthalate film





PORE DIAMETER 0.2 μm

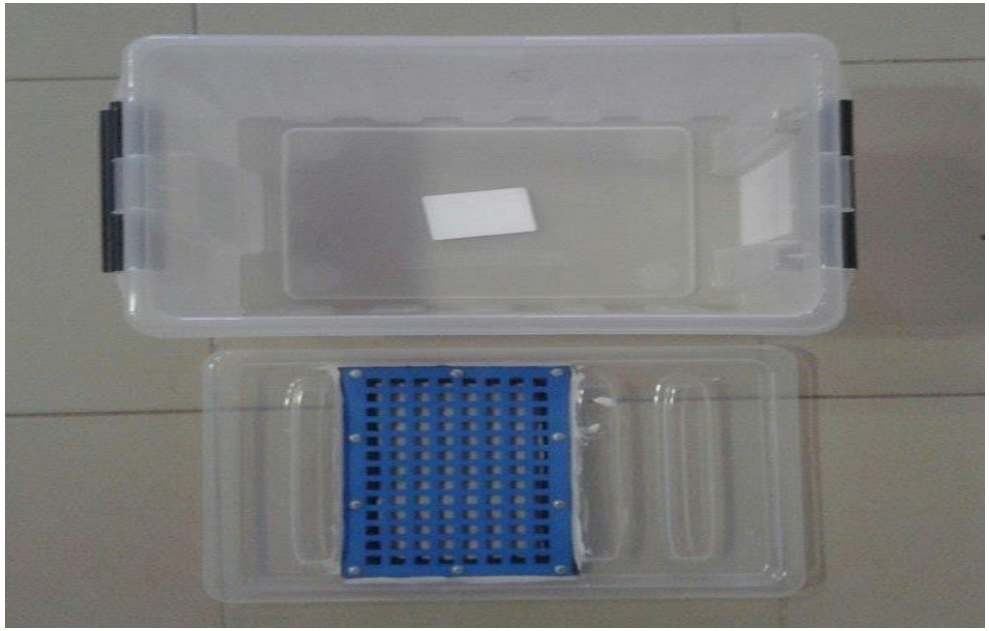
Biological method of gaseous media formation during cold storage of fruits using track membranes

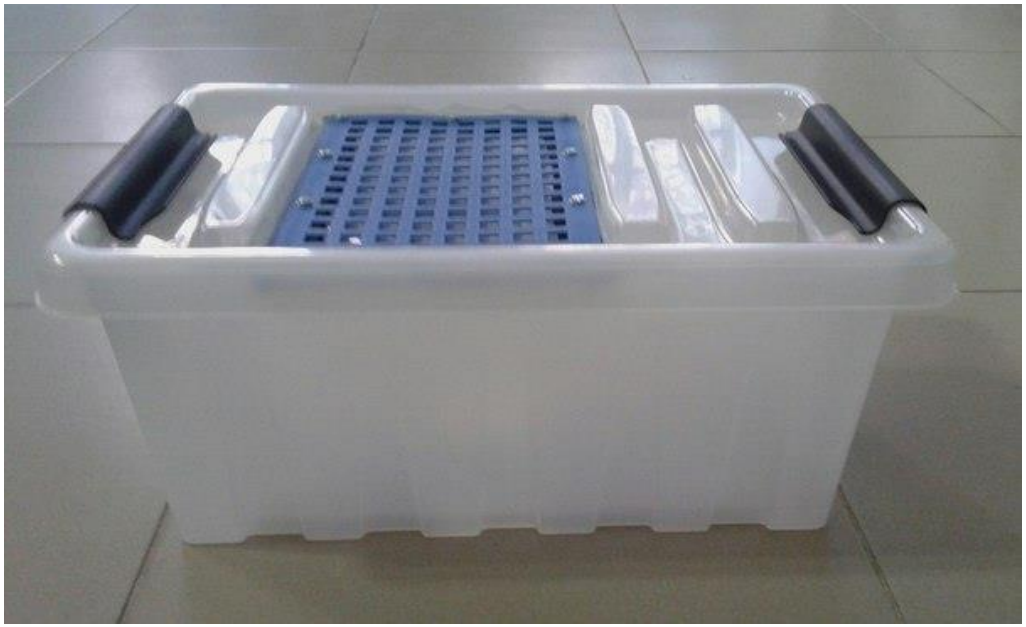
Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM),
gas composition, controlled atmosphere, respiratory rate, apples

Container equipped with GSTM





SELECTIVITY 4,0 – 5,0; LAYER THICKNESS 10 μm

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:
cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Calculation of capacity and area of gas-selective track membranes

$$S = \frac{m}{\mu}, \quad \mu = \left(\frac{C_{o_2}{}^{н}}{C_{o_2}{}^{к}} - 1 \right) \cdot \mu_0, \quad \mu_0 = \frac{pP}{J}, \quad C_{co_2} = \frac{\delta}{\sigma}(C_{o_2}{}^{н} - C_{o_2}{}^{к}),$$

S – membrane area, m^2;
μ - membrane capacity, kg/m^2;
$C^{н}_{O_2}$ - initial oxygen concentration (21%);

$C^{к}_{O_2}$ - recommended storage mode, %
p - oxygen partial pressure (2,1·10^4 Pa);
P - membrane permeability for oxygen [3,0·10^9 m^3/(s·N)];
J - respiratory rate of fruits [2,66 m^3/(kg·s)];
C_{CO_2} - carbon dioxide concentration in a stationary mode (2,0 - 0,8%);
δ - respiratory quotient (1,1);
σ- membrane selectivity (5).

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Gas composition and membrane area

Gas composition №	C_{O_2},%	C_{CO_2},%	S, cm²/kg
1	2,0	4,18	4
2	3,0	3,96	7
3	4,0	3,74	10
4	5,0	3,52	18
5	5,5	3,41	20
6	6,0	3,30	22
7	7,0	3,08	25

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

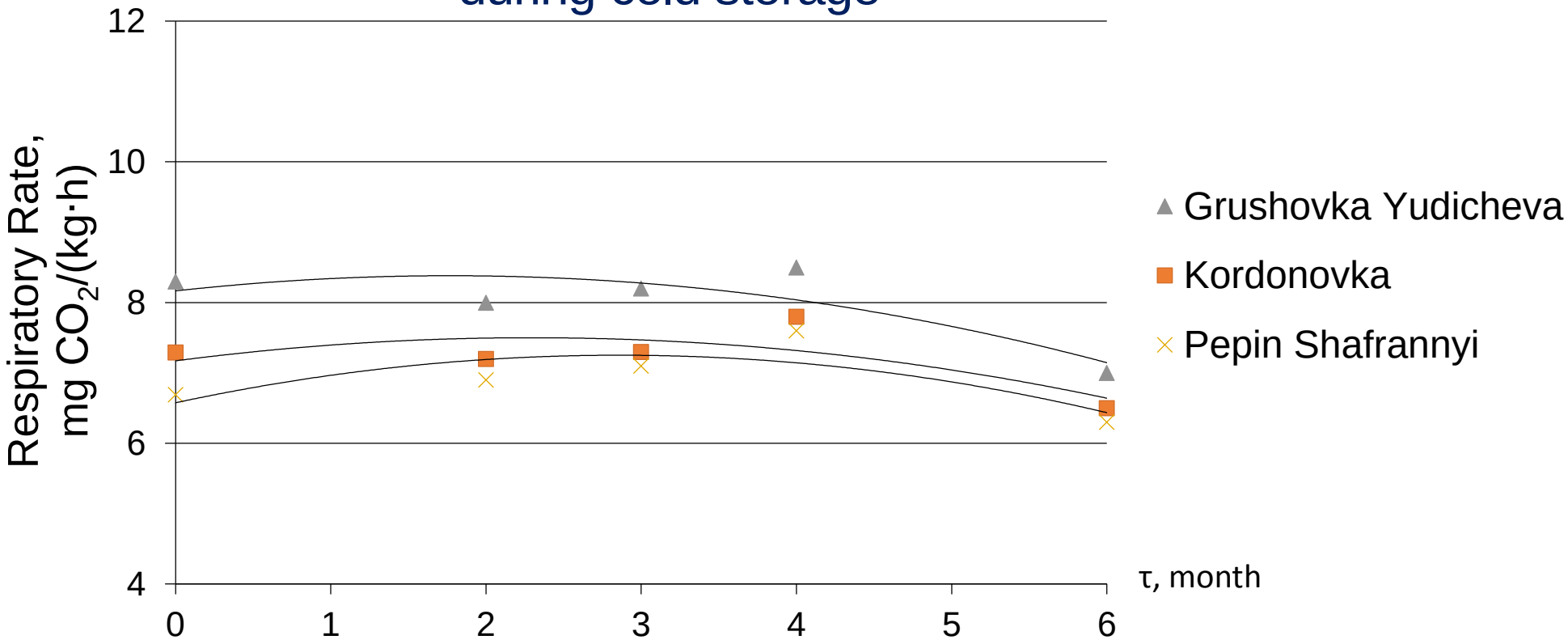
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Results:

Changes in respiratory rate in autumn varieties of apples during cold storage



Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Kinetic curves of changes in the content of the sum of mono - and disaccharides in apples during cold storage

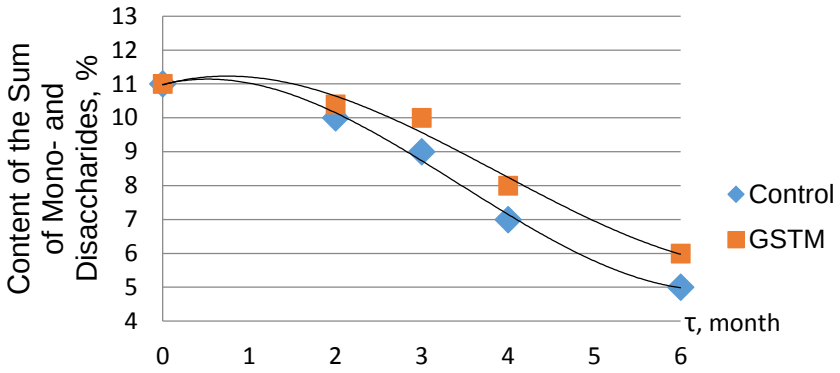


Figure 1. Changes in the content of the sum of mono - and disaccharides in "Kordonovka" apples during cold storage

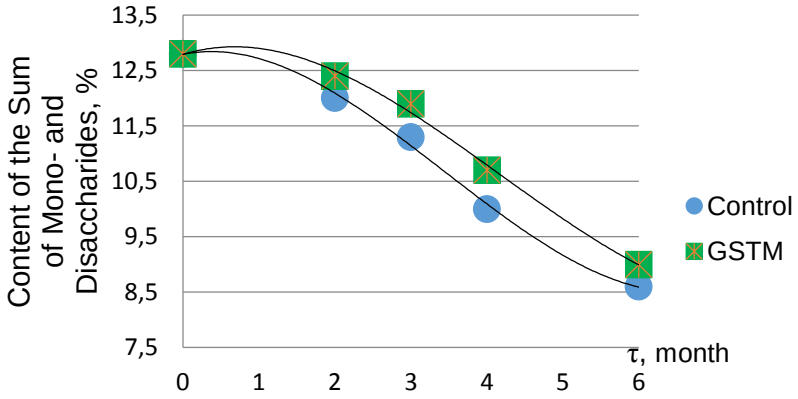


Figure 2. Changes in the content of the sum of mono - and disaccharides in "Grushovka Yudicheva " apples during cold storage

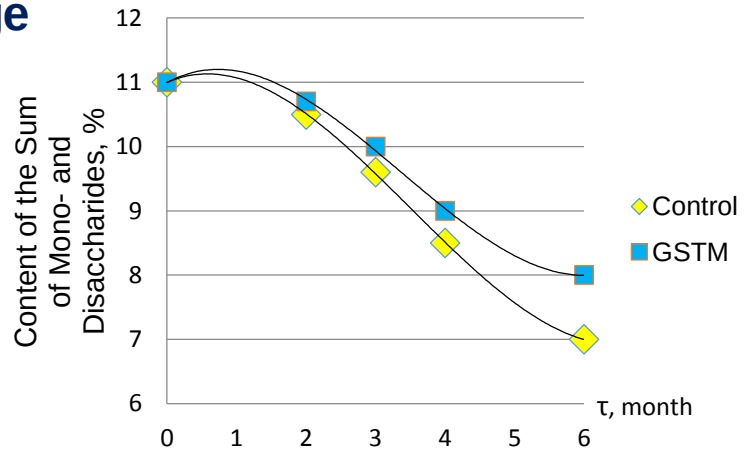


Figure 3. Changes in the content of the sum of mono - and disaccharides in "Pepin Shafrannyi" apples during cold storage

Regression equations characterizing the change in the content of the sum of mono - and disaccharides in apples of the variety:

***Kordonovka*:**

$C_{md} = 0{,}062\tau^3 - 0{,}65\tau^2 + 0{,}63\tau + 10{,}98$; R2 = 0,995 (Control);

$C_{md} = 0{,}045\tau^3 - 0{,}53\tau^2 + 0{,}72\tau + 10{,}97$; R2 = 0,981 (GSTM)

***Grushovka Yudicheva*:**

$C_{md} = 0{,}037\tau^3 - 0{,}39\tau^2 + 0{,}28\tau + 12{,}79$; R2 = 0,996 (Control);

$C_{md} = 0{,}027\tau^3 - 0{,}34\tau^2 + 0{,}42\tau + 12{,}79$; R2 = 0,995 (GSTM)

***Pepin Shafrannyi*:**

$C_{md} = 0{,}041\tau^3 - 0{,}44\tau^2 + 0{,}47\tau + 10{,}99$; R2 = 0,999 (Control);

$C_{md} = 0{,}043\tau^3 - 0{,}44\tau^2 + 0{,}58\tau + 10{,}99$; R2 = 0,998 (GSTM)

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Rate constants of oxidation reactions of the sum of mono - and disaccharides in apples of autumn varieties during cold storage

Varieties of apples	Storage conditions	τ, month	K_1, 1/month
Kordonovka	Control	6	0,131
	GSTM	6	0,101
Grushovka Yudicheva	Control	6	0,066
	GSTM	6	0,059
Pepin Shafrannyi	Control	6	0,075
	GSTM	6	0,053

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Kinetic curves of changes in the content of organic acids in apples during cold storage

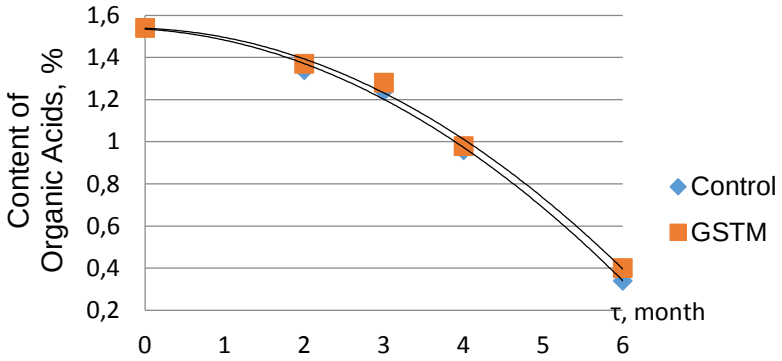


Figure 1. Changes in the content of organic acids in "Kordonovka" apples during cold storage

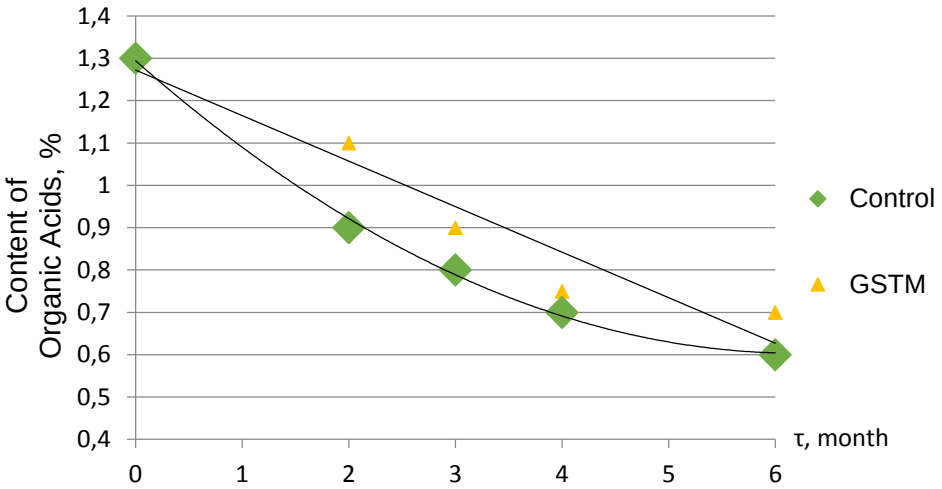


Figure 3. Changes in the content of organic acids in "Pepin Shafrannyi" apples during cold storage

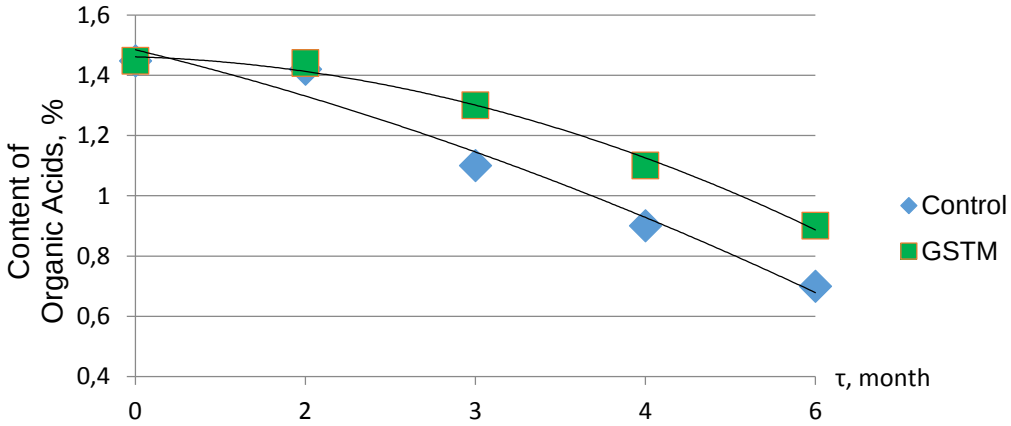


Figure 2. Changes in the content of organic acids in "Grushovka Yudicheva " apples during cold storage

Regression equations characterizing the change in the content of organic acids in apples of the variety:

Kordonovka:

$C_{oa} = -0{,}029\tau^2 - 0{,}023\tau + 1{,}53$; R2 = 0,996 (Control);

$C_{oa} = 0{,}029\tau^2 - 0{,}014\tau + 1{,}54$; R2 = 0,995 (GSTM)

Grushovka Yudicheva:

$C_{oa} = -0{,}016\tau^2 - 0{,}11\tau + 1{,}61$; $R^2 = 0{,}97$ (Control);

$C_{oa} = -0{,}031\tau^2 + 0{,}046\tau + 1{,}45$; $R^2 = 0{,}992$ (GSTM)

Pepin Shafrannyi:

$C_{oa} = 0{,}017\tau^2 - 0{,}22\tau + 1{,}29$; $R^2 = 0{,}997$ (Control);

$C_{oa} = 0{,}01\tau^2 - 0{,}17\tau + 1{,}32$; $R^2 = 0{,}958$ (GSTM)

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:
cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Rate constants of reactions of changes of organic acids content in apples of autumn varieties during cold storage

Varieties of apples	Storage conditions	τ, month	K_2, 1/month
Kordonovka	Control	6	0,252
	GSTM	6	0,225
Grushovka Yudicheva	Control	6	0,121
	GSTM	6	0,079
Pepin Shafrannyi	Control	6	0,129
	GSTM	6	0,103

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:
cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Kinetic curves of changes in the content of ascorbic acid in apples during cold storage

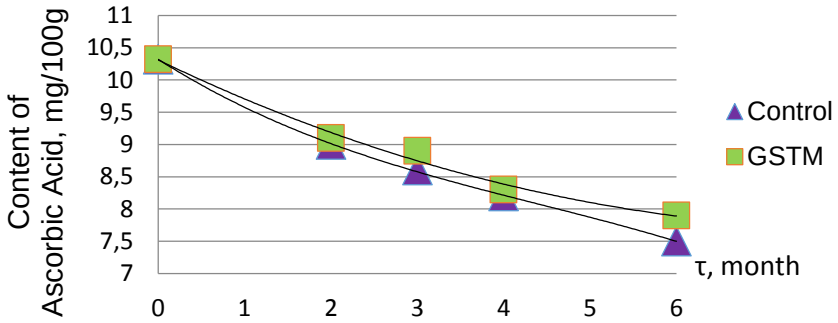


Figure 1. Changes in the content of ascorbic acid in "Kordonovka" apples during cold storage

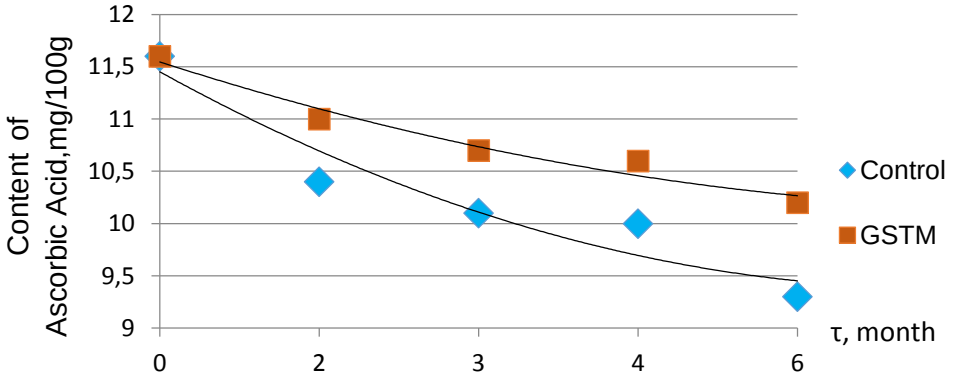


Figure 2. Changes in the content of ascorbic acid in "Grushovka Yudicheva " apples during cold storage

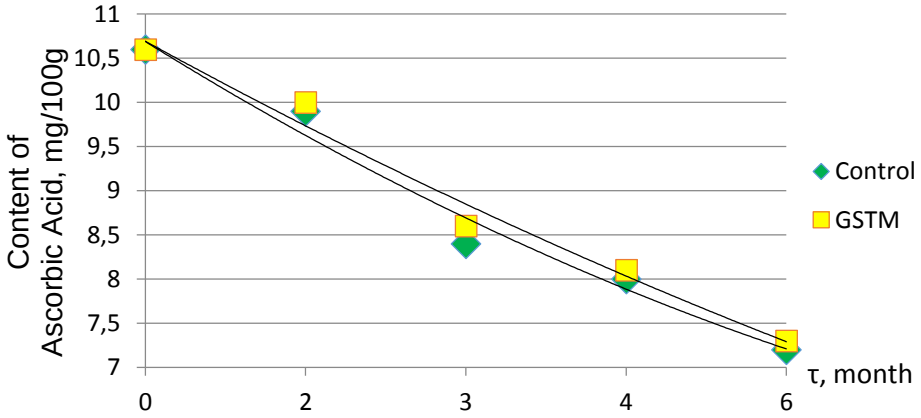


Figure 3. Changes in the content of ascorbic acid in "Pepin Shafrannyi" apples during cold storage

Regression equations characterizing the change in the content of ascorbic acid in apples of the variety:

***Kordonovka*:**

$C_{aa} = -0{,}008\tau^3 + 0{,}12\tau^2 - 0{,}85\tau + 10{,}3$; R2 = 0,999 (Control);

$C_{aa} = -0{,}001\tau^3 + 0{,}043\tau^2 - 0{,}65\tau + 10{,}3$; R2 = 0,988 (GSTM)

***Grushovka Yudicheva*:**

$C_{aa} = 0{,}085\tau^2 - 1{,}01\tau + 12{,}4$; R2 = 0,92 (Control);

$C_{aa} = 0{,}042\tau^2 - 0{,}58\tau + 12{,}1$; R2 = 0,964 (GSTM)

***Pepin Shafrannyi*:**

$C_{aa} = 0{,}064\tau^2 - 1{,}26\tau + 11{,}9$; R2 = 0,976 (Control);

$C_{aa} = 0{,}035\tau^2 - 1{,}06\tau + 11{,}7$; R2 = 0,98 (GSTM)

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:
cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Rate constants of reactions of conversion of ascorbic acid content in apples of autumn varieties during cold storage

Varieties of apples	Storage conditions	τ, month	$К_3$, 1/month
Kordonovka	Control	6	0,053
	GSTM	6	0,045
Grushovka Yudicheva	Control	6	0,037
	GSTM	6	0,021
Pepin Shafrannyi	Control	6	0,064
	GSTM	6	0,062

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova
Faculty of Biotechnologies (BioTech), ITMO University

Keywords:
cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Phytopathological indicators during cold storage, days

Varieties of apples	60 days			120 days		
	Healthy apples, %	Fusarium culmorum	Monilia fructigena	Healthy apples, %	Fusarium culmorum	Monilia fructigena
	Control					
Kordonovka	94.7	0	4.8	90.2	0	5.3
Grushovka Yudicheva	92.1	1.9	6.0	90.0	3.4	6.6
Pepin Shafrannyi	91.7	2.6	4.8	87.5	4.6	7.9
	GSTM					
Kordonovka	95.2	0	4.2	90.7	0	4.5
Grushovka Yudicheva	97.0	0	3.0	94.2	2.7	5,.2
Pepin Shafrannyi	95.4	2.0	2.6	92.0	2.0	2.6

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Conclusions

It is shown that for maximum preservation of the quality, nutritional and biological value of the studied apple varieties at t = (3 ± 1) ° C a controlled gas atmosphere of the following composition is recommended: oxygen concentration - (5.2 ± 0.1%), carbon dioxide concentration - (3.6 ± 0.1%). Controlled atmosphere was created using a gas-selective composite membrane with an area of 14-22 cm²/kg, depending on variety of apples and respiratory rate.

References

1. Babakin B.S., Voronin M.I. Energy-saving refrigeration technologies for transportation, storage and ripening of fruits. - M.: «DeLi plyus». - 2013. – 190 p.
2. Bazarnova YU.G. Methods of studying the properties of raw materials and food products– SPb: ITMO University. – 2012.- 76 p.
3. Ivanova T.N., Zhitnikova V.S., Levgerova N.S. Storage technology of fruits, berries and vegetables- Orel: OrelGTU. -2009. – 203 p.
4. Kiprushkina E.I., Kolodyaznaya V.S., CHebotar' V.K. Economic safe methods in the integrated protection and preservation of plant products // *Pishchevaya promyshlennost'* [Food industry]. 2013. №2. - pp.4 - 7.
5. Koidov, SH.M. Influence of controlled atmosphere on physiological and biochemical processes and quality indicators of fruits during cold storage / V.S. Kolodyaznaya, M.M. Danina, SH.M. Koidov // Nauchnyj zhurnal NIU ITMO. Seriya «Processy i apparaty pishchevyh proizvodstv». - 2015. - №2. - pp. 53-60. - 0,43 p.l / 0,23 p.l.
6. Kolodyaznaya V.S, Koidov SH.M. Kinetics of oxidation reactions of respiration substrates of table grape varieties during cold storage using track membranes // Vestnik Mezhdunarodnoj akademii holoda. 2015. №1. - pp.29 - 31.

Biological method of gaseous media formation during cold storage of fruits using track membranes

Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

Faculty of Biotechnologies (BioTech), ITMO University

Keywords:

cold storage, gas-selective track membrane (GSTM), gas composition, controlled atmosphere, respiratory rate, apples

Thank you for your attention!

Authors: Vasilina Kostiuk, Valentina Kolodyaznaya, Olga Rumiantceva, Elena Kiprushkina, Irina Shestopalova

Affiliations: Faculty of Biotechnologies (BioTech), ITMO University

Contact details: k_vasilina1996@mail.ru

+79214032877