ORIGINAL PAPERS

THE EFFECT OF THE POSTHARVEST APPLICATION OF FITOMAG TECHNOLOGY ON APPLE QUALITY

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Key words: *apple cultivars, storage condition, 1-MCP, physical-chemical parameters, fruit quality*

INTRODUCTION

Fruit growing in the Republic of Moldova holds a leading place in the agro-industrial sector and has a significant share in the national economy. Currently, the fruit growing of the Republic of Moldova is undergoing a period of constant development. Particular attention is paid to the selection of new apple varieties, adapted to the pedoclimatic conditions in the Republic and at the same time resistant to various disorders in the process of long-term storage under cold conditions.

Due to their nutritional and biological value, apples are permanently requested by consumers, and a special feature of them is the ability to store them for a longer period. However, during storage the fruits are affected by certain diseases, which can cause considerable loss. These losses can be reduced by several methods, one of which would be the improvement of existing storage technologies, the application of new, more modern storage methods, as well as the training of people who own companies specialized in fruit storage. Currently, unfortunately, due attention is not given to these problems in the Republic of Moldova. Moreover, extensive research in this direction is practically absent, although the losses obtained as a result of fruit storage reach maximum values.

An important factor in successfully solving storage problems is the cultivar, whose individual characteristics are genetically determined. As modern as the storage method is, if the storage capacities of the cultivar are not taken into account, then we may not receive the desired results **(**Арасимович et al., 1976).

It should be mentioned that in Moldova the most widespread method of storing apple fruit is the storage in refrigerators with artificial cooling (normal atmosphere, 21% O_2, t. +1+3°C), namely because it does not require large expenses as in the case of other methods, such as storing in refrigerators with controlled atmosphere (low O_2 and high CO_2 content), which is also used in the republic. In the last years in the Republic of Moldova more modern refrigerators have started to be built, but a small percentage of the agricultural producers can afford this. Existing technologies for storing agricultural production under normal atmosphere (NA) and controlled atmosphere (CA) have their advantages and disadvantages, but they do not offer guaranteed protection against losses. In addition, the costs of storage the fruits under controlled atmosphere are quite high Thus, under the conditions of the Republic of Moldova, as the poorest country in Europe, with a poorly developed economy and low incomes of fruit producers, a special attention deserves the implementation of the storage methods that would require less financial expenses.

Currently, in addition to storage in a controlled atmosphere, additional methods are used to inhibit ethylene biosynthesis. The US researchers synthesized an effective compound 1-methylcyclopropene (1-MCP), post-harvest treatment of which can inhibit the synthesis of ethylene, the maturation and senescense processes, significantly reduce losses and maintain the quality of the fruit (Blankenship S., 2003; Watkins C. et al., 2003). One of the effective preparations for inhibiting the synthesis of ethylene is 'Fitomag', whose active substance is 1-MCP. The preparation has been synthesized by scientists from the Russian Federation and is harmless to human health and the environment. It is registered and authorized for practical use in several countries, including in the Republic of Moldova. The application of this storage technology has proven to be effective in several countries and consists in treating climacteric fruits at the beginning of storage with this preparation. The mechanism of action consists in the attachment of the active substance of the Fitomag preparation to fruit ethylene receptors. As a result of this reaction, the biosynthesis of ethylene and α-farnesen is inhibited, the intensity of respiration, the enzymatic activity and other metabolic processes decreases. As a result, the losses caused by fungal diseases and physiological disorders are reduced. Thus, the fruits maintain their quality at a high level, and the duration of their storage period is extended. (Гудковский, 2003; Гудковский, 2005; Goudkovsky et al., 2012; Kozhina et al., 2012).

The research given could have a major contribution, largely due to the fact that the Fitomag preparation from a scientific point of view is insufficiently studied in the Republic of Moldova. In particular, its influence on the intensity of the metabolic processes in the fruits of the apple in the dynamics of storage, aimed at giving more knowledge to the fruit producers and exporters, is not investigated in greater depth. The method of storage by applying the 'Fitomag' preparation could be as an alternative for many producers and exporters of fruits from Moldova, who cannot afford the construction of refrigerators equipped with modern equipment, the advantages being: they require less sophisticated equipment, the diminution consumption of electricity during storage, simplicity in application, preservation of the taste and commercial qualities of fruits, extension of storage period.

Due to the fact that in Moldova there are other growing conditions (temperature, precipitation, real air humidity, soil chemical composition, etc.) during the vegetation period, we assumed the responsibility to carry out more detailed research on the action of the 'Fitomag' preparation during the period of storage on metabolic processes in apple fruits, cultivated under the conditions of the Republic of Moldova.

Starting from the ones described above, the purpose of the research was to evaluate the mechanism of action of the preparation 'Fitomag' in the postharvest period on the maturation-senescence processes of the fruits of the most widespread cultivars of apples, cultivated under pedoclimatic conditions in Moldova.

MATERIAL AND METHODS

Apples 'Idared', 'Golden Delicious', 'Florina', and 'Reinette 'Simirenko' (with the largest acreages in the Republic of Moldova) were collected in SRL Lefcons - Agro (Floreni district, Ungheni region, Republic of Moldova). The apples were harvested in the stage of maturity. Fruit maturity and harvest time was evaluated based on monitoring the weather conditions, by assessing the starch content (iodine/starch test), the content of soluble solids (Brix %) using a digital refractometer (model MT – 032 ATC, Germany) and fruit firmness using a penetrometer (model FT-327 pressure tester, Italy). After the harvesting, the same day, the apple fruits were transported to the experimental base "Carpotron" of the Institute of Genetics, Physiology and Plant Protection (Chisinau, Republic of Moldova). Fruits were randomly divided into 2 groups of 12 wooden crates with 100 fruits in each crate (300 fruits per cultivar). The fruits were stored for 150 days in experimental refrigeration rooms (KHT-1M) according to the scheme:

1. Normal atmosphere (NA) - control (non-treated fruits) (O_2 - 21 %, CO_2 - 0,03%). Apples were stored at 1 °C and relative air humidity of 85–90%;

2. 'Fitomag' + NA - apples treated after harvesting with 1-MCP ('Fitomag', 0.44 $g \cdot m^{-3}$, OOO "FitomagInter", Russia) in an airtight container for 24 hours, with subsequent storage under the same conditions as the control. For the post-harvest treatment of apples, a dose of 0.22 – 0.44 $g \cdot m^{-3}$ of Fitomag registered in Republic of Moldova.

Several physiological and physico-chemical parameters were investigated. Some of them will be presented in this article. Titratable acidity (TA) was determined by dissolving a known weight of sample in distilled water and titration against 0.05 N NaOH using phenolphthalein as the indicator. Flesh firmness was evaluated using at least 10 fruits, on the opposite sides of fruit using an FT-327 pressure tester (Italy), equipped with 11.3 mm tip. The results were expressed in kg/cm^2. Weight loss was determined by monthly weighing of samples using the KERN PCB 1000-2 electronic scale (Germany). Ten fruit from each cultivar were separated for the weight loss test. The weight loss (%) was calculated using the equation: Weight loss (%) = ((Fruit initial weight − Fruit weight after interval) × 100)/Fruit initial weight. The number of fruits affected by physiological disorders and fungal diseases was determined in comparison with the total number of fruits (in percentages).

The obtained results were subjected to mathematical analysis according to Microsoft Excel program package.

RESULTS AND DISCUSSION

After harvesting, many of the metabolic processes characteristic of fruits during the vegetation period continue to take place during the post-harvest period, their intensity being dependent on the conditions of storage and the characteristics of the species and the varieties. The intensity with which these metabolic processes take place after harvesting is the main factor determining the duration of their quality maintenance (Burzo et al., 1999). Thus, increasing the quality of fruits and storage them for a longer period can be achieved only on the basis of in-depth knowledge on the physiological-biochemical legitimacy of fruit quality formation and the development of scientifically confirmed methods of regulating their metabolism at all stages of fruit life.

Titratable acidity. Organic acids play one of the central roles in fruit metabolism, their content being one of the most important criteria for establishing the long-term storage capacity of fruits.

The taste properties of fruits are due not only to the sugar content, but also to other substances and primarily to organic acids. Therefore, for a correct evaluation of the quality of the fruits, it is necessary to determine the content of these substances (Ермаков, 1987). The determination of the content of

titratable acids at harvest allows to receive important information regarding the possible behavior of the cultivar in the following months of storage (Феткенхойер, 1984).

The results presented in figure 1and 2 show that the biodegradation of organic acids was conditioned both by the biological particularities of the cultivar and by the method of storage applied. Regardless of the method of storage, in all cultivars there was a tendency towards a decrease in the content of titratable acids until the end of storage. The highest consumption of acids during storage recorded the untreated fruits (Figure 1). With a higher content of titratable acids at the end of the storage period, the treated fruits were highlighted, registering higher values by 0.03 - 0.12% compared to the untreated fruits (Figure 2). The highest titratable acidity was recorded in the cultivar Reinette Simirenko (0.96%), followed by the Idared cultivar (0.63%), Florina (0.53%) and Golden Delicious (0.49%).

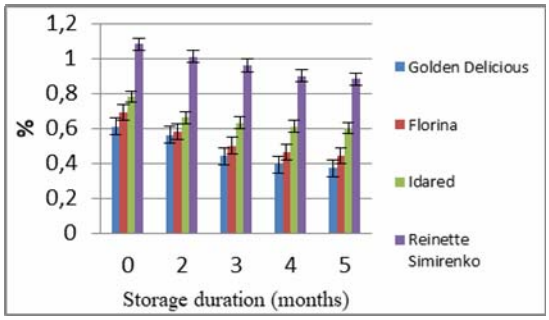

Fig. 1. Change in the content of titratable acidity in control apples

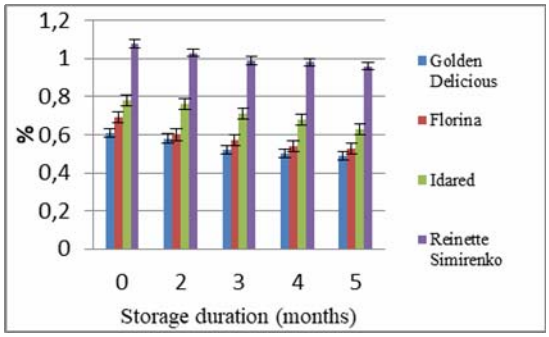

Fig. 2. Change in the content of titratable acidity in apples treated with Fitomag

Flesh firmness. Quality is a combination of many parameters, of which firmness is a very important one (Goliáš J. et al., 2008). Firmness is of particular importance in assessing the commercial value of fruits**.**

Firmness is a major quality trait of apples, and changes in this parameter after harvest depend on the postharvest handling of the fruit and on firmness at the moment of harvest (Sigal-Escalada V., 2006). The degree of firmness of fruits apart from their structure and texture also depends on their biochemical composition (Lazăr, 2006). The main reason for the decrease in fruit firmness is the enzymatic biodegradation of protopectin, which forms a binder between the cells (Burzo et al., 1999).

During the storage period there was a reduction in fruit firmness (Figure 3, Figure 4). Significant differences between varieties and methods of storage were found at the time of removal from storage. The highest values were recorded for the treated fruits (Figure 4). The preparation 'Fitomag' slowed down the aging-senescence processes, maintaining at a higher level the firmness of the fruit, with 3.88- 20.66 % compared to the control variant. The highest firmness at the end of the storage period showed the Florina cultivar fruits treated with 'Fitomag' - 6.82 kg / cm^2.

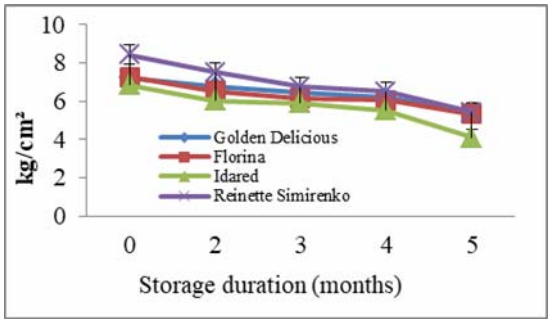

Fig. 3. Change in the flesh firmness of control apples

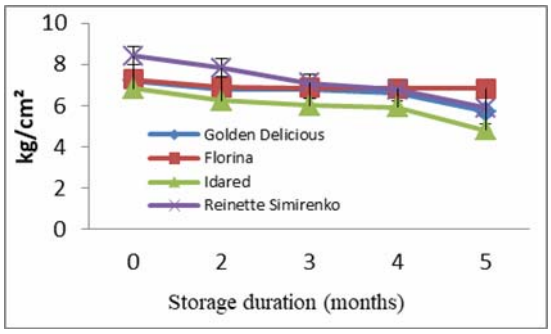

Fig. 4. Change in the flesh firmness of apples treated with Fitomag

Weight losses. Changing the water content in fruits significantly influences the quality.

It is known that during the storage period as a result of the processes of transpiration and respiration the fruits bear weight loss. After harvesting, when the connection with the mother plant is interrupted, the water supply of the fruits ceases. As a result, there is a continuous loss of water throughout the entire storage period. The intensity of this process is higher immediately after harvest, when the water content is

also higher (Burzo, 1999). High water losses shorten the storage period, the fruit loses its volume and begins to wilting. The predisposition of some fruits to wilting is also explained by the different chemical composition of the fruits (Феткенхойер, 1984). In the case of our investigations during the storage period, more obvious signs of wilting were observed in the Golden Delicious cultivar, which was even more prone to this physiological disorder.

Regardless of cultivar and method of storage, it was found that the greatest losses occur at the initial stages of the storage process and towards the end of the storage period. The most insignificant losses were observed in the fruits treated with 'Fitomag'. The increased intensity of the ripening processes of the control fruits correlated with the degree of dehydration of the meat and was higher by 0.22-2.01% compared to the treated fruits (Figure 6). The lowest weight loss was recorded in the Idared cultivar (1.90%) and the largest in the Golden Delicious cultivar (4.01%). In the case of untreated fruits, the same legality was obtained, but the weight loss was higher compared to the version with treated fruits (figure 5).

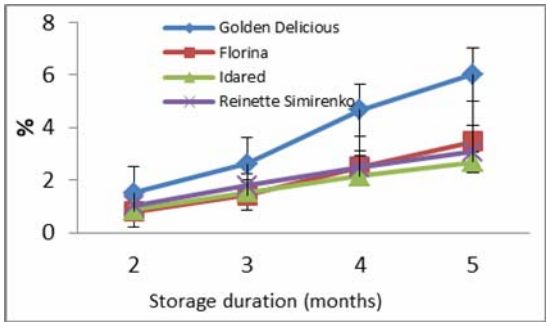

Fig. 5. Change of weight losses of control apple

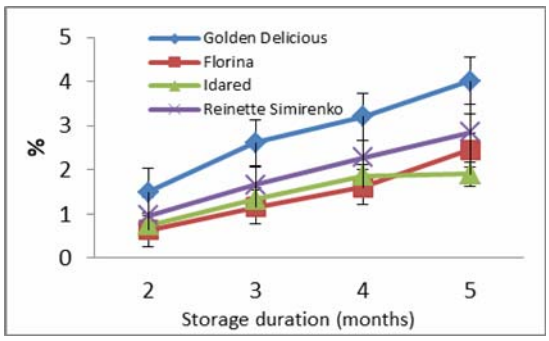

Fig. 6. Change of weight losses of apple treated with Fitomag

Healthy fruits (not affected by physiological disorders and fungal diseases). Depending on the cultivar, the amount of healthy fruits was much higher in the treated fruits, accounting for 0.46-27.13% more than the control fruits. It is worth mentioning that in the treated and untreated Idared cultivar fruits no fungal diseases or physiological disorders were detected.

CONCLUSIONS

1. The degree of modification of the physico-chemical parameters depends both on the biological particularities of the variety and on the storage conditions.
2. The results confirm the efficacy of the 'Fitomag' preparation. The high content of titratable acids in the treated fruits relative to the untreated fruits found at the end of the storage period confirms that the 'Fitomag' preparation has slowed down the biodegradation of the biochemical compounds involved in the metabolic processes.
3. Treated fruits showed a lower degree of weight loss, greater firmness, crispiness and juiciness .
4. Fitomag application decrease physiological disorders, fungal diseases and maintain higher healthy fruit amount after five months of storage.
5. Storage technology by applying the 'Fitomag' preparation does not require significant expenses and can compete with the method of storage the fruits under controlled atmosphere conditions.
6. At the Idared cultivar there were no significant differences between the treated and untreated fruits and based on the data obtained, it can be assumed that under the conditions of the Republic of Moldova this cultivar is capable of being kept under atmosphere normal conditions (temp. 1°C and 21% O_2) without the fruits being treated with ethylene synthesis inhibitors.

ABSTRACT

The purpose of the research was to evaluate the mechanism of action of the preparation 'Fitomag' in the postharvest period on the maturation-senescence processes of the fruits of the most widespread cultivars of apples ('Idared', 'Golden Delicious', 'Florina', and 'Reinette Simirenko'), cultivated under pedoclimatic conditions in the Republic of Moldova. Several parameters have been studied, some of which (titratable acidity, firmness, weight loss, the amount of healthy fruits) are presented in this article. Fruits were collected in harvesting maturity and treated with 1-MCP at the recommended dose ('Fitomag', 0.44 $g \cdot m^{-3}$). Apples were stored for five months at the temperature of 1°C and humidity 85–90%. As a result of treating the fruits with the Fitomag preparation, the processes of biodegradation of the biochemical compounds have slowed down, the fruits have retained their firmness, aroma, crispiness, juiciness and reduced the degree of fungal diseases and physiological disorders. Research has shown that postharvest use of Fitomag treatments is promising for maintaining fruit quality and can compete with the method of storage under controlled atmosphere.

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