SMARTFRESH INFLUENCE ON THE MAINTENANCE OF APPLE QUALITY

Andrew Cumpanici, Arthur Macari, Viorel Leahu
Technical University of Moldova, 168 bd. Ştefan cel Mare, Chisinau, Republic of Moldova
Phone (+373 22) 509958, email: acumpanici@yahoo.com

Abstract
Appropriate post-harvest handling is essential to maintain the quality and extend the shelf-life of fresh fruits, which is a requirement for the Moldovan farmers in order to be competitive on the European Union market and the expanding supermarket chains of CIS countries. Ethylene is a plant hormone which generate an avalanche of biochemical reactions leading to the ripening and softening of the fruit and, eventually, to the loss of quality and commercial value. The carried out studies show that the SmartFresh treatment of apples stored in gas-tight rooms leads to the slowing of negative effects of ethylene, thus the fruits maintain their firmness, juiciness, taste, and color for a longer period, and the incidence of some physiological disorders is controlled or reduced (scald, bitter pit, etc.). The SmartFresh technology, which does not require significant initial investments, is of particular interest for the Moldovan apple growers, Although it was commercially introduced only recently (years 1999-2000), the SmartFresh technology is already extensively used by the main apple growing countries in the world (EU, USA, China, Japan, Chile) and is approved for use in Moldova since 2008.

Keywords: SmartFresh, 1-methylcyclopropene, controlled atmosphere (CA), ethylene, firmness, apples, storage, post-harvest treatments.

1. INTRODUCTION

Appropriate post-harvest handling is essential to maintain the quality and extend the shelf-life of fresh fruits, which is a requirement for the Moldovan farmers in order to be competitive on the European Union market and the expanding supermarket chains of CIS countries.

The fruits and vegetables are living organisms. After harvesting, in their tissues complex metabolic processes occur (respiration, ripening etc.) under the catalytic action of own enzymes. Several researchers (Burzo [1], Metlițkii [2]) identified that, during apple storage, ethylene – the ripening hormone - is being produced, which is the key factor is the above-mentioned processes. It is being synthesized in the cells of all fruits during the growing and development stages [3, 4]. During the ripening stage of climacteric fruits, the ethylene has a key role, its synthesis being auto-catalytic.

Ethylene is a plant hormone which generate an avalanche of biochemical reactions leading to the ripening and softening of the fruit and, eventually, to the loss of quality and commercial value. Limiting the effects of ethylene slows the natural senescence of the fruit, thus extending the maximum shelf-life of the product. In addition to the currently recommended methods of ethylene management (harvesting fruit at an earlier phase of maturity, before ripening stage and quick cooling of the fruit as soon as possible after harvesting), a special interest is attached to the research on the technology of treating stored apples with the SmartFresh ethylene inhibitor (active ingredient 1-methylcyclopropene, 1-MCP).

In order to reduce the vital activity of vegetal organs, to control some physiological disorders, to reduce the respiration intensity, the fruits are cooled and stored in rooms with normal or controlled atmosphere (CA). The apples stored in CA conditions have a longer shelf-life due to the fact that, beside temperature and relative humidity of the air, the composition of the atmosphere is modified through special systems (O_2: 1-3%, CO_2: 1-3%, N: 94-98%). The CA/ULO technologies (Controlled Atmosphere / Ultra-Low Oxygen) have a development potential for the Moldovan apple growers because they allow and

availability of fruits till the months of January-May, when the prices are much higher than during the harvesting season. The transition to CA/ULO technologies is made difficult by the significant investments required to refurbish the older cold storages. That why alternative technologies such as SmartFresh, which don't required significant upfront investments, is of particular interest for the Republic of Moldova. Although it was commercially introduced only recently (years 1999-2000), the SmartFresh technology is already extensively used by the main apple growing countries in the world (EU, USA, China, Japan, Chile).

2. MATERIALS AND METHODS

As SmartFresh is a growth regulator (ethylene inhibitor) applied for the fruits stored in gastight areas, the trial scheme was developed considering guidelines included in the following documents:

1. EPPO PP 1/255(1) Standard: Regulation of growth in pome fruits by post-harvest and in store applications [6];
2. OECD Guidance on Objective Tests to determine Quality of Fruits and Vegetables and dry and dried produce AGR/CA/FVS(2005)3/REV1[7];
3. GOST 25555.0 -82 Fruit and vegetable products. Methods for the determination of titratable acidity;
4. GOST 28562-90 Fruit and vegetable products. Refractometric method for determination of soluble solids content;
5. Methodic guidelines for the testing of chemical and biological means of plant protection from pests, diseases and weeds in the Republic of Moldova [5].

The research was carried out for both types of storages that are used by Moldovan apple growers:

1. Storage for 5 months in regular atmosphere rooms, controlling the temperature and the relative humidity of the air (RA storage)
2. Storage for 5 months on controlled atmosphere rooms, where in addition to temperature and relative humidity control, there is the possibility to change the air composition (CA storage).

3. EXPERIMENT DESCRIPTION

The research was conducted on two varieties planted on large areas in the Republic of Moldova: Jonagold (bicolor variety: red and green) and Reinette Simerenko (green color).
In the day of harvesting, the apples were transported to the cold storage of Codru-ST Ltd (Bucovăț, Strășeni) were the treatment was carried out. Half of the harvested apples were treated with SmartFresh during 24 hours in special tents of 4 m^3, while the remaining apples served as control variant. After the treatment both variants („Control" and „SmartFresh") were directed based on the trial scheme: to RA storage, to CA storage and to the laboratory to determine quality parameters at harvest.

4. RESULTS AND DISCUSSIONS

4.1 Exterior aspects

In all cases and for both varieties it was determined the ability of SmartFresh to maintain the color of apples. In the case of Reinette Simerenko the apples from the "Control" variant at the end of the storage got a yellowish coloring, while those of "SmartFresh" variant had a green color close to the initial coloring at the harvest. In the case of Jonagold, the intensity of the red color remained intact, while the background color remained green for the treated apples, while it changed to yellow for the "Control" variant.
SmartFresh treatment significantly reduced the severity of greasiness for both varieties: Jonagold and Reinette Simerenko. Although the greasiness is still present on the treated apples, it is not any more a negative factor for the consumer perception of fruit quality. The combined effect of maintained coloring and reduced greasiness give to the treated apples a much "fresher" aspect, more appealing to consumers.

4.2 Firmness

The non-treated apples stored in RA conditions had an out-of-storage firmness below the threshold of 6 kg/cm^2, while the treated apples surpassed that limit in all cases. In all analyzed cases, the Tukey test identified statistically significant differences between the "Control" and "SmartFresh" variants.

Table 1 Firmness evolution for Reinette Simerenko apples (kg/cm^2)

Variant	At harvest	RA storage	CA storage
Control	11.70	5.97	7.10
SmartFresh		9.76	10.07

DL_{05}= 0.82

For Jonagold apples, at the end of the 5-month storage, in all cases, the apples from the "Control" variant had a firmness much lower than the reference level of 6 kg/cm^2 (in average by 28%), while all those from the "SmartFresh" variant surpassed that level (in average by 13%).

Table 2 Firmness evolution for Jonagold apples (kg/cm^2)

Variant	At harvest	RA storage	CA storage
Control	7.76	4.16	4.64
SmartFresh		6.62	6.90

DL_{05}= 0.8

4.3 Total soluble solids (TSS) content

For Jonagold apples, in all cases and variants of treated apples, an increase of TSS content during storage was observed, due to starch conversion into sugars. At the same time, the "Control" variant had a lower TSS content than the "SmartFesh" variant and the TSS content at harvest. The Tukey test has not identified statistically significant differences between „Control" and „SmartFresh" variants.

Table 3 TSS content evolution for Jonagold apples (%)

Variant	At harvest	RA storage	CA storage
Control	14.55	14.09	14.15
SmartFresh		15.61	15.18

DL_{05}= 1,67

For Reinette Simerenko apples, in all cases and variants, an increase of TSS content during storage was observed, due to starch conversion into sugars. In all cases, the Tukey test identified statistically significant differences between the "Control" and "SmartFresh" variants.

Table 4 TSS content evolution for Reinette Simerenko apples (%)

Variant	At harvest	RA storage	CA storage
Control	11.24	14.75	14.61
SmartFresh		15.04	15.09

DL_{05}= 0.70

4.4 Titrable acidity expressed as malic acid concentration

For Jonagold apples, the titrable acidity decreased during the storage, this being more pronounced for the „Control" variant (in average it was lower by 49% in comparison with „SmartFresh" variant). However the Tukey test identified statistically significant differences only in the case of RA storage.

Table 5 Titrable acidity evolution for Jonagold apples (%)

Variant	At harvest	RA storage	CA storage
Control	0.38	0.14	0.24
SmartFresh		0.26	0.30

DL_{05}= 0.08

For Reinette Simerenko apples, the titrable acidity decreased during the storage, this being more pronounced for the „Control" variant (in average it was lower by 29% in comparison with „SmartFresh" variant). In all cases, the Tukey test identified statistically significant differences between the "Control" and "SmartFresh" variants.

Table 6 Titrable acidity evolution for Reinette Simerenko apples (%)

Variant	At harvest	RA storage	CA storage
Control	0.93	0.61	0.61
SmartFresh		0.74	0.74

DL_{05}= 0.12

4.5 Physiological disorders

The research identified the ability of SmartFresh to control some physiological disorders.
Thus, in the case of RA storage of Reinette Simerenko apples, 48% of control fruits were affected by superficial scald, while it was not present in the SmartFresh-treated fruits.
In the case of RA storage of Jonagold apples, 10% of fruits were affected by watercore, while it was not present in the SmartFresh-treated fruits.

5. CONCLUSIONS

The research of biological efficacy of SmartFresh treatment determined the following:

1. SmartFresh treatment positively influences a series of apple quality parameters:
    a. Maintenance of firmness
    b. Maintenance of titrable acidity
    c. Maintenance of TSS (only in some cases, in smaller degree than in the case of firmness and acidity)
    d. Maintenance of fruit coloring
    e. Control of some physiological disorders (senescence scald and watercore)
2. Taking into consideration the above-mentioned positive effects, the use of SmartFresh technology will increase the export competitiveness of the Moldovan fresh fruit sector and will enhance the food security by extending the availability of fresh fruits for the domestic market.

6. REFERENCES

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