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# Study of the apple parameters'variation during refrigeration storage

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***Abstract***

The study purpose was to observe the evolution of chemical and physical parameters variation during apple refrigeration storage such as weight losses, core temperature and dry matter for 24 days considering that the determinations were made with a three day frequency. For the experiment were chosen three apples varieties: Golden Delicious, Jonathan and Starkrimson. The apples were stored in three variants (bulk and packed in LDPE foil and ordinary paper) in a professional refrigerator.

As a result of these determinations the lower core temperature (2°C) was registered for bulk Golden Delicious apple in the 19th day of refrigeration and the highest is attributed to Jonathan paper packed (5.8°C) in the 4th day of storage. The dry mater increasing is higher for the Strakrimson variation most in the bulk case (with 50.74% bigger than before the storage). The bigger weight loss (10 g) was registered for Jonathan apple paper packed.

***Keywords***: Golden Delicious, Jonathan, Starkrimson, refrigeration, bulk, LDPE foil

## 1. Introduction

Fruit quality varies from year to year, and depends largely on growing conditions during the vegetative season. Nonetheless, the changes in fruit quality parameters that occur during the ripening period follow the same pattern every year. [1-5].

To ensure maximum storability, apples should be picked when mature, but not fully ripe. If apples are picked when they are too ripe, physiological processes are underway which complicate storage, even under optimal conditions [1,5]. Apples picked at right stage have the organoleptic qualities which enable them to survive more than six months of storage.

Most fruit quality parameters are useful not only for gauging fruit maturity, but for evaluating the eating quality of the apple as well [6]. Fruit firmness is a measure of texture. Soluble solid content, acidity and sugar content are associated with taste. Volatile substances contribute to fruit aroma. Many factors affect fruit quality, including genetics, soil properties, and weather conditions.

Among fruits crops, apple represents the 4th place worldwide with 56 millions tones annually (FAO, 1998). The nutritive value is well known and represents the vari¬able content of sugar, proteins, ascorbic acid, and mineral substances.The consumption of fresh fruits or juice, food pastes, jellies, jams assure the vitamins for a better life.

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Apples are a part in all food diets and its therapeutic value is well known for different illnesses (determines the absorption of gastric secretions, the elimination of toxins, has diuretic effect).

To ensure the highest fruit quality at the end of long storage, apples must be harvested when mature but not when fully ripe. If harvested too early fruits are smaller, have reduced flavour and colour, and are more susceptible to scald, bitter rot and internal breakdown.

Fruit does not die when harvested. It remains a living organism that continues to take in oxygen and give off carbon dioxide. After harvest, an apple no longer receives nutrients from the tree and, since it is still respiring, it must use the food it has stored over the growing season. As this food is gradually used up during storage, the sugar, starch, and acid content of the apple change. Eventually the tissue breaks down; the apple becomes mealy, and develops an "off" fl avor. Loss of water can cause the fruit to become rubbery. Proper apple storage preserves the quality of the fruit by slowing ripening and reducing water loss.

Low temperature slows the respiration rate and preserves good quality. Apples last several times longer at 17°C than they do at 39°C. Most apple cultivars should be stored at 15 to 17°C for optimum storage. If possible, the storage temperature should remain constant. The freezing temperature of apples is 14 to 16°C, so it is best not to store apples in unheated locations where the temperature may get too low. Once thawed, frozen apples deteriorate quickly, resulting in softening of flesh and loss of texture. Relative humidity must be kept high, between 90 and 95 percent, in a fruit storage area. If the humidity is not maintained, apples dehydrate and shrivel, particularly Golden Delicious.

Apples can be kept well in humid cellars that maintain a cool temperature below 22°C. They also can be stored in unheated outbuildings or garages, in Styrofoam chests, or with hay or other insulating materials piled around them to prevent them from freezing. Apples should be kept in containers lined and covered with polyethylene to help retain the humidity [12].

Mass reduction by water loss is greater in earlier picked apples because waxy surface is not completely formed at this moment [7,8]. Early picked fruits are smaller and their surface in a storage unit is larger. Because water transpiration depends on fruit surface area too, small fruits loss their weight faster. Another reason of more intensive evaporation is structure of fruit cuticle, which is not fully developed when fruits are harvested too early. At the same time the cuticle is the first barrier that pathogens have to challenge [9]. Later picked apples often are over mature and all physiological processes are underway what complicate storage, even under optimal conditions [1,8]. Apples harvested too late are vulnerable to mechanical injures, sensitive to low temperature breakdown, water core and more rot [10]. At optimal harvest time picked apples have the organoleptic qualities [11], which enable them to survive more than six months of storage.

## 2.Materials and methods

*Materials:* fruits (pome fruits – apples – Golden Delicious, Starkrimson and Jonathan), LDPE (Low Density Polyethylene) foil and alimentary paper.

*Instalations/equipments:* core product thermometer type AMPROBE TPP1-C1, professional refrigerator with temperature and humidity sensor, scale Owa Laborator, portable refractometer.

*Methods.*The fruits were stored, using a professional refrigerator, at 5˚C. The storage was made in three variants: bulk and packed using LDPE foil and alimentary paper for a total period of 24 days.

As main analyses there were determined: the apples'core temperature, the water losses and dry matter (soluble solid content).

Temperature measurements were made with a four day frequency, inside the storage space and in the apples' core. To determine the water losses during storage, the apples were weighted, before and after the storage at the same interval of four days. The soluble solid content was determined using a direct method by refractometry.

## 3.Results and discussions

The aim of the study was to evaluate the effects of refrigeration storage in restaurants or public alimentary units over apples' parameters. Because this preservation method is very used for fruit since the consumption moment is suitable to determine the changes occurred during refrigeration.

So in this order, the apples were stored, using a professional refrigerator at 5˚C. The storage was made in three variants: bulk and packed using LDPE foil or alimentary paper for a total period of 24 days. Relative humidity had been kept between 85 and 90%, in the apple storage area.

In Figure 1 is represented the core temperature variation for bulk apples. In the first graphic it can be observed a similar evolution of the slopes for the temperature variation for Golden Delicious and Starkrimson variety, but the Jonathan curve is having more inflexions negative points (in 4, 10, 14, 18 days of storage).

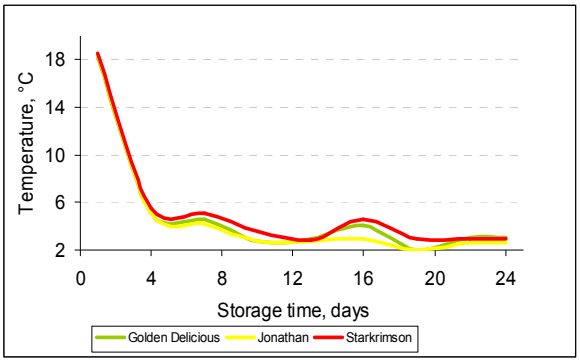


***Figure 1.*** Core temperature variation for bulk apples

In the first instance after the apple refrigeration received at room temperature (18°C), it has registered a sudden and uniform decreasing of the temperature (5-5.5°C) in apples' core, which concurs with the first four days of refrigeration.
This temperature has been manifested different values related to the variety, for Golden Delicious and Jonathan the shock temperature was 5°C, while for Starkrimson was 5.5 °C.

In Figure 2 is represented the core temperature variation for alimentary paper packed apples. So here it can be observed that the slopes allure is similar, so the variation of the storage temperatures for alimentary paper packed apples. Also it can be observed that the highest temperature was registered for Starkrimson variety (4.6°C in the 16$^{th}$ day of storage) and the lowest temperature is registered for Golden Delicious variety (2°C in the 19$^{th}$ day of storage).

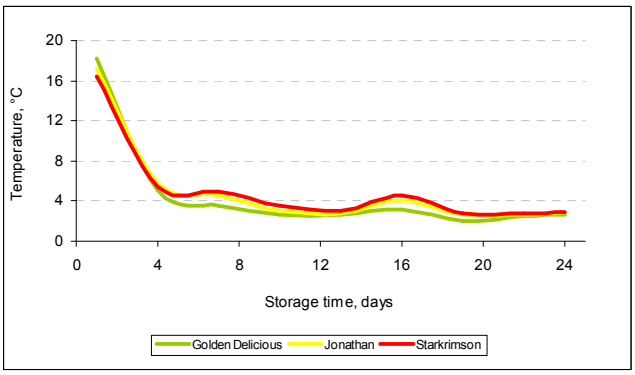


***Figure 2.*** Core temperature variation for alimentary paper packed apples

In Figure 3 is represented core temperature variation for LDPE foil packed apples. For the 3$^{rd}$ graphic the allure of the slopes for Jonathan and Golden Delicious are similar, while the Starkrimson's curve presents 4$^{th}$ modulations also negatives and positives (for 4, 8, 12 and 16 days of storage).

After 12 days of storage at refrigeration the core temperature for all package varieties has been standardized for all the apples (2.7-2.9°C for Golden Delicious, 2.7-2.8°C for Jonathan and 2.8-3.0°C for Starkrimson). These value intervals denote that the three varieties had a similar evolution over the 12 days storage period.

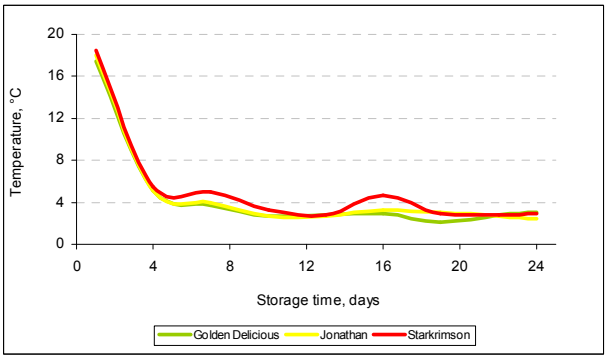


***Figure 3***. Core temperature variation for LDPE foil packed apples

The highest value of the apples' core temperature (4.6°C) has been registered in the 16th day of storage for Starkrimson variety in all package variants.

Near to the final interval of storage at 20 days of refrigeration the lowest temperature (2°C) has been registered for Golden Delicious variety alimentary paper packed, respectively for bulk Jonathan.

In figure 4 is represented the bulk apples soluble solid content.

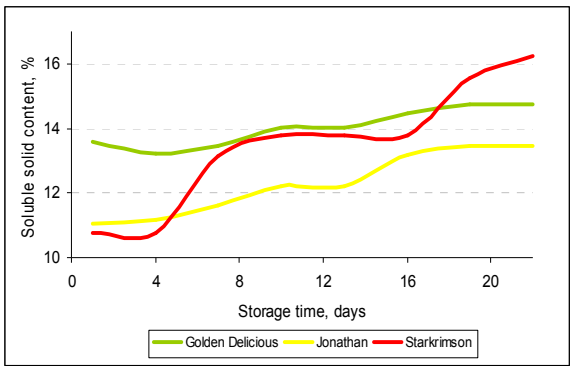


***Figure 4.*** Soluble solid content for bulk apples

The allure of the curves for bulk Golden Delicious and Jonathan variety is similar, so the both varieties have the same variance. The Starkrimson variety has the biggest increasing of the soluble solid content to storage, with 50.74% bigger than before the storage.

The lowest increasing for the soluble solid content is presented by Golden Delicious variety 8.45% bigger than before the storage.

In Figure 5 is represented the soluble solid content. for alimentary paper packed apples.

The soluble solid content is similar for Golden Delicious and Jonathan varieties. The increasing for Golden Delicious has the lowest value (with 15.46% bigger than before storage), while the Starkrimson variety has the biggest value for the soluble solid content (with 44.71% bigger than before storage). Also it can be observed that in the 10$^{th}$ day of storage for Starkrimson variety the soluble solid content has increased sudden from 11.3% to 13.8%.

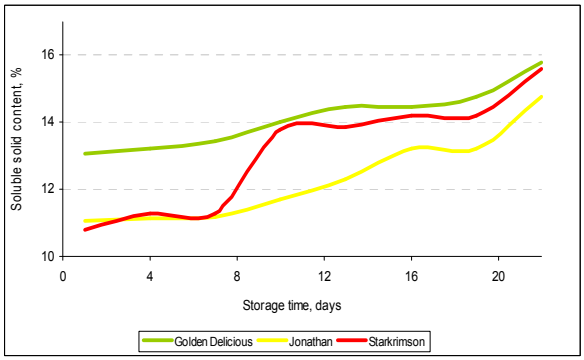


***Figure 5.*** Soluble solid content for alimentary paper packed apples

In Figure 6 is represented the soluble solid content for LDPE foil packed apples.

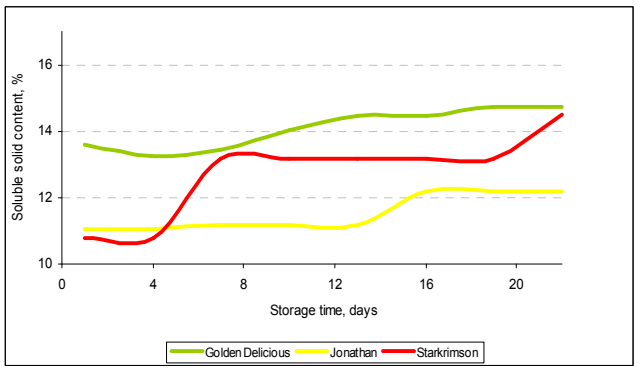


***Figure 6.*** Soluble solid content for LDPE foil packed apples

The Golden Delicious variety has the most uniform slope; Jonathan has one increase from the 12$^{th}$ to the 16$^{th}$ day of storage from 11.16% to 12.2% soluble solid content.

Also here Starkrimson has a sudden increasing in the 7$^{th}$ day of refrigeration from 10.78% to 13.15%. The increasing for the soluble solid content for LDPE foil packed for all apple varieties is lower than for the bulk and the alimentary paper package.

In Figure 7 is presented the weight variation of bulk apple.

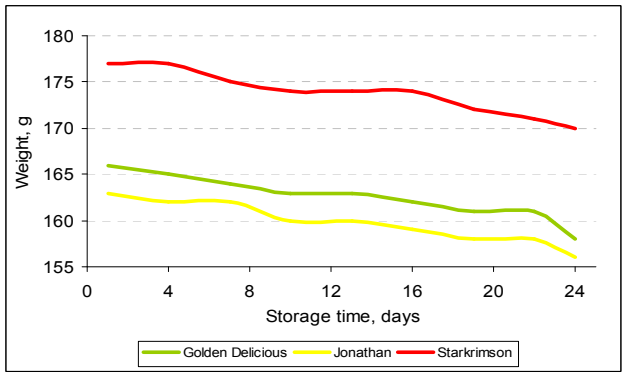


***Figure 7.*** Weight variation of bulk apple

The water losses variation during the refrigeration storage of the bulk apple was almost the same for the three varieties. The water variation being an uniform decreasing during the 24 days of storage.

In Figure 8 is presented the weight variation of alimentary paper packed apple.

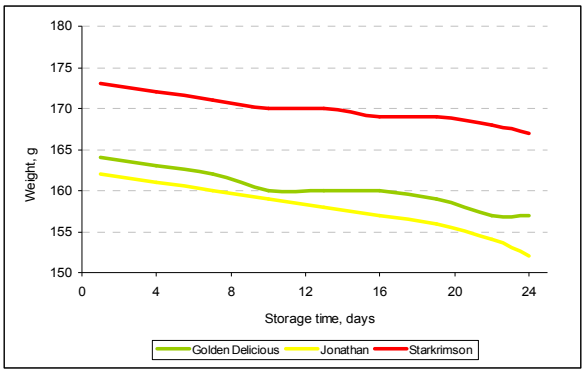


***Figure 8.*** Weight variation of alimentary paper packed apple

The weight variation of alimentary paper packed apples is lower than that for the bulk apples, excepting the Jonathan variety where the quantity of water losses is bigger with 3 g than in the bulk case.

In Figure 9 is presented the weight variation of LDPE foil packed apple.

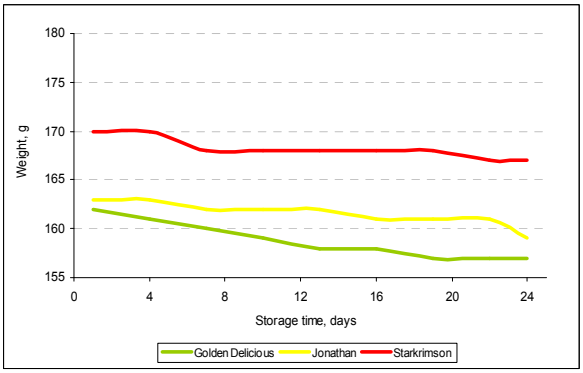


***Figure 9.*** Weight variation of LDPE foil packed apple

As it can be denoted from this graphic the water losses associated to weight decreasing are lower than from the other variants (bulk and paper packed). The Starkrimson variety registered the lower loss 3 g, but neither the other two varieties have bigger losses.

All the values for the weight variation of LDPE foil packed apple are lower compared with the other two variants (3-5 g for the three varieties).

## 4. Conclusions

The apple storage by refrigeration is a technique for quality fruit preservation using refrigeration temperatures. As low temperature slows the respiration rate and preserves the good quality of the apples.

A final conclusion drawn by the core temperatures determinations for the three apple varieties is that the packed apples has been stored better than the bulk one, also the Golden Delicious is the most suitable variety to be refrigerated.

A final conclusion regarding the soluble solid content is Golden Delicious is the most suitable apple variety to be stored at refrigeration temperatures and the LDPE package allows the least water lost.

The better results for the weight losses have gained by the Starkrimson variety for all types of package. But the best package for this type of storage is LDPE foil.

The closest correlations were found between water and sugar loss in refrigerating storage. The water percentage lost by all apple varieties during storage in LDPE package is correlated with the lower values registered for the soluble solid content.

**Aknoledgments**

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**Refrences**

1. Braun H., Brosh B., Ecker P., Krumbock K., Changes in quality off apples before, during and after CA-cold storage, *Obstau und fruchteverwertung*, **1995**, *45*(5-6), 143-206
2. Eccher Zerbini P., Pianezzola A., Grassi M., Poststorage sensory profiles of fruit of apple cultivars harvested at different maturity stages, *Journal of food quality*, **1999**, *22*(1), 1-17, doi: 10.1111/j.1745-4557.1999.tb00922.x
3. Zude-Sasse m., Herold B., Geyer M., Huyskens-Keil S, Influence of maturity stage on physical properties in apple, *Acta horticulturae*, **2001**, *553*(1), 109-110
4. Kvikliene N., Influence of harvest date on physiological and biochemical processes in apple fruit, *Horticulture and vegetable growing*, **2004**, *23*(2), 412-420
5. Ingle M., D'Souza M.C., Townsend E.C., Fruit characteristics of York apples during development and after storage, *Horticultural science,* **2000**, *35*(1), 95-98
6. Hoehn E., Gasser F., Guggenbuhl B., Kunsch U., Efficacy of instrumental measurements for determination of minimum requirements of firmness, soluble solids, and acidity of several apple varieties in comparison to consumer expectations, *Postharvest biologic technology*, **2003**, *27*(1), 27-37, doi: http://dx.doi.org/10.1016/S0925-5214(02)00190-4

7. Zerbini P. E., Pianezzola A., Grassi M., Poststorage sensory profiles of fruit of apple cultivars harvested at different maturity stages, *Journal of Food Quality*, **1999**, *22*(1), 1–17, doi: 10.1111/j.1745-4557.1999.tb00922.x
8. Juan J. L., Frances J., Montesinos E., Camps F., Bonany J., Effect of harvest date on quality and decay losses after cold storage of Golden Delicious apples in Girona. *Acta Horticulturae*, **1999**, *485*, 195–201
9. Ihabi M., Rafin C., Veighie E., Sancholle M., Storage diseases of apples: orchard or in storage. In: First transnational workshop on biological, integrated and rational control. Lille, Service Regional de la Protection des Vegetaux, Nord Pas-de Calais, 1998**,** 91–92.
10. Ingle M., D'Souza M. C., Townsend E. C., Fruit characteristics of York apples during development and after storage, *Horticultural Science*, **2000**, *35*(1), 95–98
11. Hribar J. Plestenjak A., Simcic M., Vidrih R., Patako D, Influence of ecological conditions on optimum harvest date in Slovenia, 1996
12. Casals M., Bonany J., Carbo J., Alegre S., Iglesias I., Molina D., Casero T., Recasens I. Establishment of a criterion to determine the optimal harvest date of 'Gala' apples based on consumer preferences, *Journal of Fruit and Ornamental Plant Research*, **2006**, *14*, 53–63
13. U.S. Department of Agriculture (USDA), *Harvesting and storing apples***,** 1994