

THE INFLUENCE OF STORAGE CONDITIONS ON SOME QUALITY PARAMETERS AND HEALTH PROMOTING COMPOUNDS IN FOUR APPLE VARIETIES

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Abstract

Apples are one of the basic components in modern human nutrition. They are a food which can be consumed without any additives, either fresh or consumed as juice, sauce, jam, cider, marmalade etc. The huge number of varieties with staggered ripening at different times and the ability to keep fresh for a long time, winter varieties, provides fresh fruit consumption almost throughout the year, about 10 months in a year. In our study, changes on some quality parameters and secondary metabolites in 4 apples varieties, during prolonged storage in the cellar and ultra low oxygen (ULO) were investigated.

Key words: apples, ultra low oxygen, cellar, secondary metabolites

INTRODUCTION

Apple (*Malus domestica* Borkh.) is the fourth most important fruit crop after citrus, grapes and banana, and one of the commercially most important horticultural crops grown in temperate parts of the world (Ferree and Warrington, 2003). *Malus domestica* contains over 7500 cultivars that have originated from different countries in the world. Many cultivars have desirable characteristics which make them suitable for cultivation under specific conditions, but only a few dozen of these are grown commercially on a worldwide scale (Moore et al., 1991).

However, fruit quality is strongly dependent on storage and shelf-life conditions. Thus, the shelf-life of apples is affected by a number of previous factors, including associated growing, harvesting, and/or storage technologies. The goal of storage must be to extend fruit 'keepability' while maintaining or enhancing consumer acceptability. Storage technology of apples has been the subject of many studies. From a commercial point of view, regimes have been optimized to minimize losses due to physiological disorders and maximize the retention of firmness during long term storage.

However, apples stored for long periods must also meet consumer expectations (Hoehn et al., 2003).

Storage conditions determine the longevity of storage life of apples. Some apples varieties showed a rather rapid decrease of flesh firmness during air storage (Goliáš et al. 2000). Controlled atmosphere storage with ultra-low oxygen (ULO) concentration has been widely adopted to extend the apple storage period thereby reducing the loss of firmness, acidity and sugars (Ferrandino et al. 2001).

The aim of this study is to investigate some quality parameters (moisture/dry weight; water soluble dry weight and acidity), and health protecting components like: total polyphenols, flavonoids and vitamin C, of 4 apple varieties (Mutsu, Gala, Golden and Idared) immediately after harvest and after 5 month of storage in cellar or in ULO conditions.

MATERIAL AND METHOD

The experiments were performed in 2014-2015, at the Laboratory of Secondary Metabolites in Food Industry, of Faculty for Environmental Protection, University of Oradea.

For this study, 4 apple varieties (Mutsu, Gala, Golden and Idared), from SC Havita Derecske-Hungary, were taken. It was made 3 repetition for every sample.

Sample A – immediately after harvest

Sample B – after 5 month of storage in ULO conditons – on SC Havita deposits.

Sample C - after 5 month of storage in cellar.

Quality parameters

Moisture– indirect method in forced draft oven, at $103\pm 2^{\circ}\text{C}$ (AOAC,1999).

Water soluble dry matter – of the tested samples were determined with digital refractometer KRUSS model AR 2008.

Titration acidity – volumetric determination. Apple extract in water was titrated with NaOH 0.1N and the results were expressed as % malic acid.

Health protecting components

Samples preparation

For each sample it was made the alcoholic extraction: 10 g of each sample were mixed with 10 ml ethanol solution (50%), and after 30 minutes were filtered. Ethanol extracts were diluted than 1/10 with ethanol solution (50%) (Moigrădean et al., 2007).

Total Phenolic content

The total phenolic (TP) content was determined by using the Folin-Ciocalteu (1927) colorimetric method developed by Singleton and Rossi (1965). A diluted extract (0.5 ml) or phenolic standard was mixed with 2.5 ml Folin- Ciocalteu reagent and after 5 minutes 2.0 mL sodium carbonate (7.5%). The absorption was read after 2 h at 20°C, at 750 nm. For the preparation of calibration curve 0.5 ml aliquot of 0.2, 0.4, 0.8 and 1.2 µM/ml aqueous gallic acid solution were used as the standard and expressed as mg of gallic acid equivalent (GAE) (Gergen, 2004).

Total Flavonoid compounds content

The total Flavonoid compounds content (FC) was measured with AlCl₃ colorimetric assay (Atanassova et al, 2011). The absorbance was measured at 510nm. As standard we used catechin.

Ascorbic acid (Vitamin C)

Ascorbic acid was extracted using metaphosphoric acid and the extract was titrate with iodine solution starch indicator (Kallner,1986).

RESULTS AND DISSCUSIONS

Quality parameters

Results obtained after performing analyses for quality parameters determination in selected apple samples were content in table 1.

Table 1.

Calculated values for health protecting components of selected forest fruits

Fruits	Nr. sample	Dry weight %	Water soluble dry matter °Brix	Titrable acidity % malic acid
		mean±sd	mean±sd	mean±sd
Mutsu	A	18.1±0.2	12.1±0.65	0.56±0.01
	B	15.06±0.1	12±0.36	0.45±0.01
	C	17.8±0.25	9.7±0.21	0.37±0.02
Gala	A	17.0±0.14	14.46±0.1	0.34±3.29
	B	11.97±0.3	11±0.05	0.28±0.26
	C	16.0±0.17	8.2±0.02	0.2±0.95
Golden	A	17.94±0.28	14±0.14	0.33±0.02
	B	14.86±0.20	12.95±0.17	0.3±0.01
	C	17.5±0.36	10.9±0.16	0.22±0.01
Idared	A	16.66±0.05	11.9±0.04	0.56±0.01
	B	13.32±0.1	12.2±0.04	0.52±0.01
	C	14.54±0.1	8.6±0.03	0.29±0.02

Analyzing the results, it can be seen that during storage at controlled atmosphere ULO (Ultra Low Oxygen), the fruits preserved qualitative characteristics, from harvest time, because physiological processes are minimized, unlike traditional household keeping in cool cellars. Several studies have been conducted to define the use of ULO partial pressures

(Zanella, 2003; Weber et al, 2011), to suppress fruit metabolism, and to obtain higher fruit quality by reducing losses.

Highest total dry weight was recorded at Mutsu variety (18.1%) and Golden (17.94%) immediately after harvest, and 17.8% for Mutsu and 17.65% for Golden at ULO storage under controlled atmosphere.

The lowest value of total dry matter was registered for Idared immediately after harvest (16.66%) and after 5 month of ULO storage 15.54% . Storage in the cellar of all the varieties has decreased due to lower dry moisture content. The highest values were obtained for the variety Golden 15.86% followed by Mutsu, Idared and Gala.

Water-soluble dry matter was represented mostly by sucrose. Sucrose content decreases during storage and increase the content in reducing sugars - glucose and fructose.

The titrable acidity decreases during storage in cellar, so during this kind of storage, apples are sweet.

The varieties with the most important changes in dry weight and water soluble dry matter were Idared and Gala.

After storage in controlled atmosphere(ULO), differences were lower between (1.61 to 7.61%) for dry weight and 8.1% for water soluble dry substance), but after storage in cellar, changes were between 11.59 and 29.5%. These results were similar with previous experiments results (Truter, Eksteen 1987; Lau 1990; Blazek et al, 2003).

In terms of total acidity during storage in ULO, Mutsu and Gala varieties has the highest level of decrease, but not more than 19%, and for storage in cellar at the end of the five months, acidity has decreased up to 48% for Idared and 41% for apples of Gala variety (table 1).

The results of our investigations coincide with the results of other researchers, the changes in fruit qualitative parameters are smaller when fruits are stored in a modified atmosphere (ULO) than when they are stored in the normal atmosphere (Drake and Eisele, 2007; Viskelis et al, 2011).

Health protecting components

Results obtained after performing analyses for health protecting component determination in selected apple samples were represented in fig 1 and 2.

Total Phenolic content - Analyzing the obtained results, the highest decrease of total polyphenol content was registered in Gala variety (with 6.4% in ULO storage, and with 57% in cellar) and the smallest decreases were registered in Idared 1.9%, for ULO storage, and with 22,3% in the cellar).

Total Flavonoid compounds content –

Total Flavonoids in the highest amount was registered in Golden apples variety and the smallest in Gala variety. Decreases in total flavonoid was

10% in Mutsu and Idared variety after ULO storage, in comparison with the values obtained in the moment of harvest, and much higher 48.3% for Gala and 55% for Idared variety in case of storage in cellar.

Ascorbic acid (Vitamin C)

Vitamin C was found in the largest quantity in Idared and Gala, and the lowest amount was recorded for the variety Mutsu. After storage in ULO, the vitamin C content of Golden variety decreased with 14% and Gala with only 2.7%, but if the apples are stored in normal household, in cellar, a significantly higher decrease was registered, reaching 21% in Mutsu and 44.7% in Idared.

These results are in accordance with previous reports, which have shown that apple has a high polyphenol content, differed depending on apple cultivar and on storage conditions, (Drogoudi et al., 2008; Khanizadeh et al., 2008; Vieira et al., 2009).

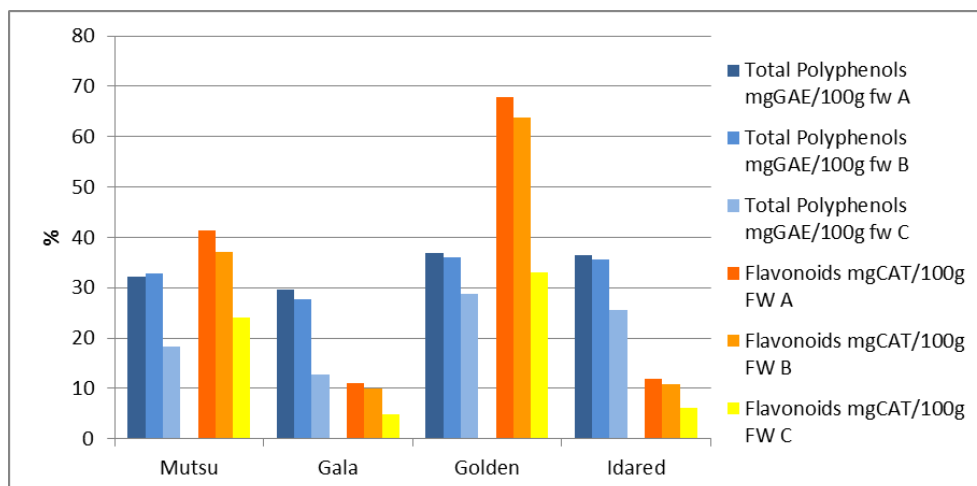


Fig.1 Graphical representation of mean values of total polyphenol and flavonoid content in the studied apple varieties

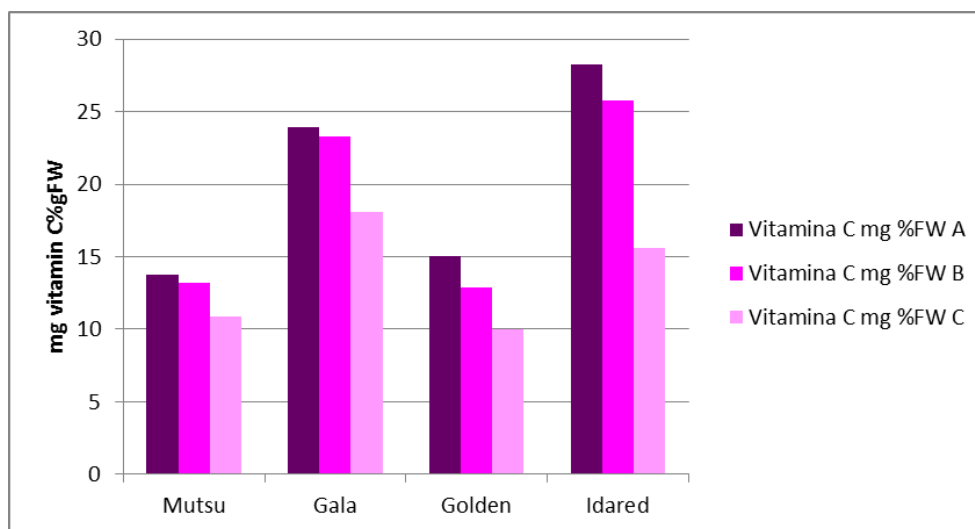


Fig.2 Graphical representation of mean values of vitamin C content in the studied apple varieties

CONCLUSIONS

In order to ensure the quality of apples production after harvest it is necessary to apply a modern storage technologies, ensuring regular control of quality indicators (sugar, acidity, vit.C content, etc.) of the stored production.

It should be noted one of the basic ideas of modern storage: the purpose of this activity is not necessary for preventing decreases of the quality of stored products, but to slowing down physiological processes in apples to contribute to the achievement of their maximum taste.

Quality parameters and health promoting compounds in the four studied apple varieties remain relatively stable during storage at controlled Atmosphere (ULO). Thus it is not only that fruit quality attributes are greatly preserved and storage losses reduced as much as possible, but also the time span of fruit usage is extended.

Consuming varieties with a high content of antioxidants even after storage, can contribute to a diet rich in antioxidants and may provide health benefits.

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