Enzymatic Changes in Minimally Processed Apples

J. SCHOVÁNKOVÁ[1], E. COCCI[2], H. OPATOVÁ[1] and M. DALLA ROSA[2]

[1]Department of Food Preservation and Meat Technology, Institute of Chemical Technology, Prague, Czech Republic, *E-mail: jana.schovankova@vscht.cz; [2]Università degli Studi di Bologna, Facoltà di Agraria, Cesena, Italia

Abstract: The impacts of chemical treatment and modified atmosphere on enzymatic changes in minimally processed apples were evaluated. Slices of apple cultivars Golden Delicious and Red Delicious were packed in plastic bags with modified atmospheres: 85% N_2, 5% O_2, 10% CO_2 (MA) and 78% N_2, 21% O_2, 1% other gases (NA). The changes in colour, firmness, polyphenoloxidase activity, total phenols content and concentration of single phenols during storage were measured. It has been found that the effects of storage atmosphere and antioxidant treatment were not as important as the choice of apple cultivar. Red Delicious is a cultivar with high concentration of phenolic compounds and high activity of polyphenoloxidase; therefore it is difficult to limit the very fast enzymatic changes and subsequent discoloration.

Keywords: apple; modified atmosphere; enzymatic changes

INTRODUCTION

Recently the consumption of minimally processed fruit has increased as a response to the demand for quality and modern way of consumers' life [1]. Fresh apples are one of the most consumed fruit and represent an important part of the human diet; therefore they are subjected to minimal processing.

However, the shelf life of minimally processed apples is limited by enzymatic browning which originates in mechanical operations (such as handling, peeling and cutting) during minimal processing and depends on cultivar and maturity of fruit.

During minimal processing the enzyme polyphenoloxidase (PPO) is released from the vacuoles and in the contact with phenols the reactions start. This copper-containing enzyme catalyses two reactions: the hydroxylation of monophenols to *o*-diphenols (cresolase activity) and oxidation of *o*-diphenols to *o*-quinones (catecholase activity). *O*-quinones are highly reactive compounds that are converted nonenzymatically to coloured pigments called melanines, which are responsible for less attractive appearance and lost of nutritional quality [1].

There exist many ways to inhibit the activity of PPO. However, for minimally processed apples is not suitable to use physical treatment such as thermal treatment [2]. Therefore chemical methods in combination with modified atmosphere and low temperature are used. Reducing agents (e.g. ascorbic acid) and enzyme inhibitors (e.g. citric acid) are used for the mild chemical inhibition.

EXPERIMENTAL

Plant material. Cv. Golden Delicious and Red Delicious from the store Apofruit in Cesena were used. Apples were stored in normal atmosphere at 1°C.

Sample preparation. All apples were washed, dried, hand-peeled, cored and cut into 1 cm thick slices. Then they were dipped for 10 min in the antioxidant solution (0.5% (w/v) ascorbic acid, citric acid and calcium chloride) in the rate of product/solution 1:4. After drainage 200 g of apple slices was packed in the plastic bags (PE/PA/PE, thickness 85×10^{-3} mm, water vapour transmission 2.25 g/m^2/24 h in 60% RH, oxygen permeability 50 cm^3/(m^2 24 h bar) at 23°C, carbon dioxide permeability 175 cm^3/(m^2 24 h bar) at 23°C) under two different atmospheres (85% N_2, 5% O_2, 10% CO_2 (MA) and 78% N_2, 21% O_2, 1% other gases (NA))

and stored in the dark for 8 days at 4°C. The samples were analysed every two days.

Methods. Analysed parameters were colour (spectrophotometric determination – system CIE – *L**, *a**, *b**), firmness (penetration test), total phenol content (spectrophotometric determination with Folin-Ciocalteu reagent), PPO activity (spectrophotometric determination), concentration of ascorbic acid (HPLC method), concentration of single phenols (HPLC method).

RESULTS AND DISCUSSION

Colour

Apple cut surface darkening is the limiting factor of minimally processed apple shelf-life. The most important colour parameter is *L** value which is the indicator of darkening.

During storage the value *L** decreased rapidly during the first two days of storage. This decrease was connected with the consumption of substrate by PPO and conversion phenols to the quinones. Very significant difference between apple cultivars has been found. The effect of modified atmosphere was not so important.

Firmness

The tissue firmness was disrupted by mechanical operations and enzyme activity. Calcium chloride in antioxidant solution was used for maintenance of minimally processed products tissue firmness. Under influence of this treatment the firmness of apple slices was only slowly decreasing during storage.

Activity of polyphenoloxidase

The PPO activity was limited by samples dipping in the antioxidant solution, especially by ascorbic acid and citric acid. However, the concentration of ascorbic acid containing in slices significantly decreased during two days after packaging; therefore the activity of PPO increased. During next days the activity was slowly decreasing probably

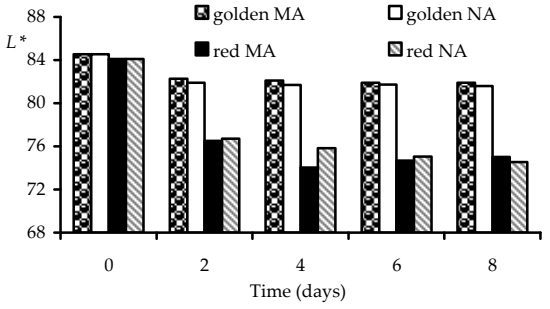

Figure 1. Value *L**

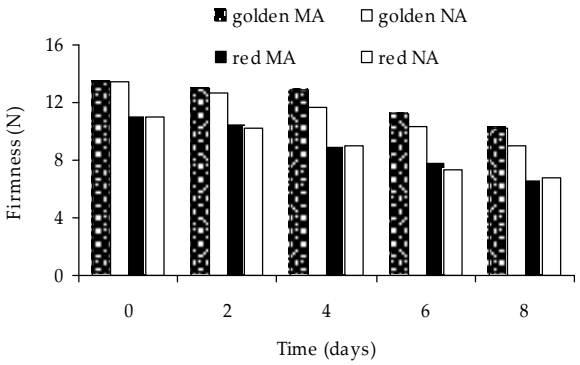

Figure 2. Firmness (N)

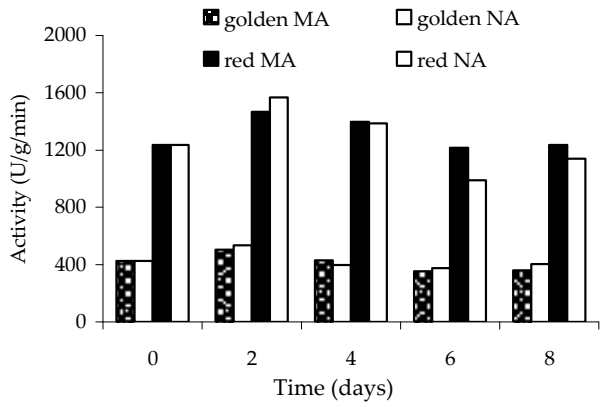

Figure 3. Activity of polyphenoloxidase (U/g/min)

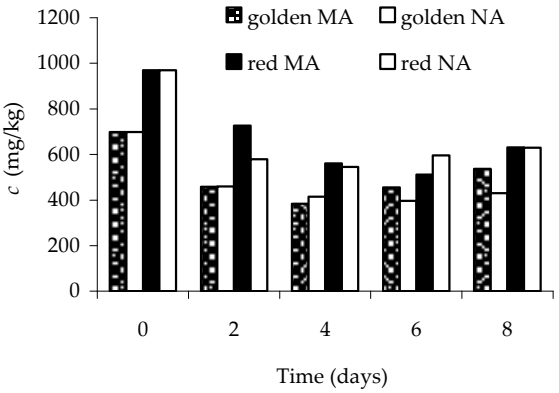

Figure 4. Total phenols content (mg/kg)

Table 1. Concentration of phenols (cv. Golden Delicious) during storage in MA (mg/kg)

	0. day	2. day	4. day	6. day	8. day
Catechin	9.30	8.92	9.06	8.80	8.83
Chlorogenic acid	134.34	119.62	111.93	110.26	117.12
Epicatechin	48.29	47.70	48.22	44.08	44.50
Caffeic acid	12.27	11.09	11.02	9.91	10.27
Phloridzin	12.60	10.88	8.75	9.21	9.27

Table 2. Concentration of phenols (cv. Golden Delicious) during storage in NA (mg/kg)

	0. day	2. day	4. day	6. day	8. day
Catechin	9.30	9.42	8.93	8.78	8.70
Chlorogenic acid	134.34	119.02	112.98	107.71	111.06
Epicatechin	48.29	45.07	46.05	41.87	42.32
Caffeic acid	12.27	11.48	11.20	10.02	10.17
Phloridzin	12.60	10.10	7.76	6.23	5.62

Table 3. Concentration of phenols (cv. Red Delicious) during storage in MA (mg/kg)

	0. day	2. day	4. day	6. day	8. day
Catechin	25.02	22.92	18.86	20.13	18.05
Chlorogenic acid	144.06	105.02	102.02	98.90	106.52
Epicatechin	75.73	67.68	63.93	57.60	57.81
Caffeic acid	21.55	20.52	23.05	19.32	20.86
Phloridzin	20.20	20.58	21.22	18.53	19.58

Table 4. Concentration of phenols (cv. Red Delicious) during storage in NA (mg/kg)

	0. day	2. day	4. day	6. day	8. day
Catechin	25.02	23.62	21.35	19.94	17.88
Chlorogenic acid	144.06	98.07	99.24	93.77	97.98
Epicatechin	75.73	67.30	62.99	58.00	58.74
Caffeic acid	21.55	21.65	22.76	21.42	19.45
Phloridzin	20.20	18.66	18.78	19.12	18.30

due to low concentration of oxygen in modified atmosphere inside the packages.

Total phenols content

The content of total phenols significantly decreased during first two days of storage. The decrease was due to high activity of PPO.

Concentration of single phenols

Chlorogenic acid, catechin, epicatechin, phloridzin and caffeic acid are the most important phenolic compounds of apple pulp. Concentration of the phenolic compounds decreased during storage. Chlorogenic acid was identified as the main substrate of enzymatic browning.

CONCLUSION

The choice of apple cultivar for minimal processing is the most considerable. Golden Delicious was identified as a cultivar with low concentration of phenolic compounds and low PPO activity. Red Delicious was qualified as a cultivar with high concentration of phenolic compounds and

high PPO activity. Therefore Golden Delicious is more suitable cultivar for minimal processing. Red Delicious is less suitable because of the rapid discoloration and changes in texture; therefore is better for direct consumption.

Chemical treatment, modified atmosphere and low temperature during storage are necessary for prolongation of the minimally processed products' shelf life.

References

[1] Cantos E., Tudela J.A., Gil M.I., Espin J.C. (2002): J. Agric. Food Chem., **50**: 3015.

[2] Rocha A.M.C.N., Morais A.M.M.B. (2001): Int. J. Food Sci. Tech., **36**: 425.