Phenolic Compounds of Apples in the Relation to the Postharvest Diseases

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Abstract: This investigation deals with the antifungal activity of naturally occurring phenolic compounds and the metabolism of plant phenolics during the cold storage. In the experiment the apple cultivars with different diseases resistance were analyzed in the relation to changes in phenolic content.

Keywords: apples; postharvest diseases; antifungal activity; phenolic compounds; storage

INTRODUCTION

Because of an increasing development of organic production, it is very important to know the resistance of fruits to storage diseases. Physiological and fungal diseases of apples are an important source of wastage and economic losses of long-stored apples. The decay of apples during the storage depends on the storage conditions and the physiological stage of apples.

Physiological disorders (e.g. superficial scald and Brown core) refer to the break down of tissue that is not caused by pathogens invasion or by mechanical damage. The disorders may develop in response to an adverse environment, especially temperature or a nutritional deficiency during growth and development.

Lenticel rot, apple scab, blue and grey mould rot are the main fungal diseases of apples. The most important species of rotting of apples are *Gleosporium album, Gleosporium perennans, Penicillium expansum* and *Monilia fructigena.*

Recently the fungistatic properties of phenolic compounds have been proved. The most important polyphenols with supposed protective activity in apples are chlorogenic acid, caffeic acid, (–)-epicatechin, (+)-catechin and phloridzin. The concentration of these phenolic compounds depends on the variety of apples and their maturity.

EXPERIMENTAL

Materials and methods. Plant material: Apple fruit of the cv. Golden Delicious, Angold, Gala, Zuzana, Melrose, HL 704A and Topaz were analyzed. The storage temperature was 2°C. The concentration of phenolic compounds was measured every month (since February to April). During storage some varieties of apples becoming susceptible to fungal attack (*Monilia fructigena* and *Penicillium expansum*). For analyzing the phenolic compounds the peel and pulp were separated into two samples: infected tissues with the rotten zone and healthy tissues surrounding the rotten zone.

Analysis of phenolic compounds. A slightly modified chromatographic method used by Gonzáles [1, 2] was used. Five grams of fresh peel and pulp were extracted at room temperature in the absence of light with methanol containing 1% of 2,6-di-*tert.*-buthyl-4-methylphenol (BHT) in an ultrasonic bath for 1 h. Solutions to be analyzed were filtered through a membrane filter 0.45 μm pore size.

The chromatographic separation was carried out with Zorbax C_8 column (150 mm × 4 mm) at room temperature. Mobile phase was classified as A (0.01M phosphoric acid) and B (0.01M phosphoric acid in acetonitrile). The gradient program was as follows (Table 1). The flow rate was 1.0 ml/min. Detection was done at 250 nm, 280 nm and 325 nm.

Table 1. Gradient elution conditions A (0.01 M phosphoric acid) and B (0.01 M phosphoric acid in acetonitrile)

Time (min)	5	15	20	22	28	28.1
A (%)	95	80	60	20	20	95
B (%)	5	20	40	80	80	5

The sample injection volume was 10 µl. The total run time was 35 min.

RESULTS AND DISCUSSION

Tables 2 and 3 show the levels of phenolic compounds of apple peel and pulp. In agreement with the literature, chlorogenic acid was the major compound in the apple pulp [3, 4]. During storage the concentrations of phenolics in the apple peel and pulp showed biosynthetic increasing.

With the presence of a pathogen, in apple pulp a significant increase in phenolics has been found, especially chlorogenic acid, (–)-epicatechin and phloridzin, in the healthy parts of the apple tissue and also in rotten tissue (Figure 1). Figure 2 shows that an increase of phenolic compounds in apple peel was observed only on the tissue surrounding the rotten zone.

Table 2. Content of phenolic compounds in apple peel and pulp (mg/kg) in February

	Gala	Golden	Topaz	Zuzana	Angold	Melrose
Peel						
Catechin	7.49	–	–	10.92	0.69	10.85
Chlorogenic acid	10.26	19.59	1.14	24.19	–	111.49
Epicatechin	7.49	12.69	45.85	25.46	51.20	17.74
Caffeic acid	–	–	–	–	–	–
Rutin	15.08	36.46	–	31.90	21.50	8.06
Phloridzin	3.03	11.52	3.76	3.20	6.06	6.88
Pulp						
Catechin	–	–	7.67	–	9.03	–
Chlorogenic acid	39.10	27.94	38.12	49.29	40.70	158.35
Epicatechin	21.90	18.03	–	37.10	–	23.15
Caffeic acid	2.58	1.46	–	–	2.90	3.79
Rutin	–	–	2.93	4.05	2.64	2.69
Phloridzin	5.45	8.82	3.94	6.48	9.54	6.05

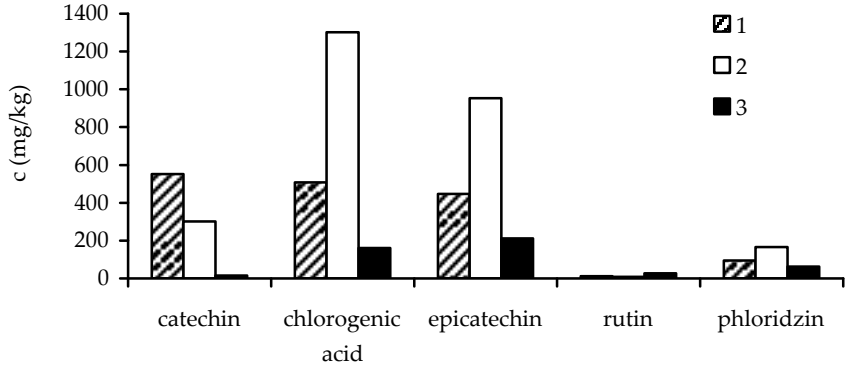

Figure 1. The content of phenolic compound in apple pulp (variety Angold) of rotten zone of infected apple tissue (1), of healthy tissue surrounding the rotten zone (2) and of non-infected apple (3)

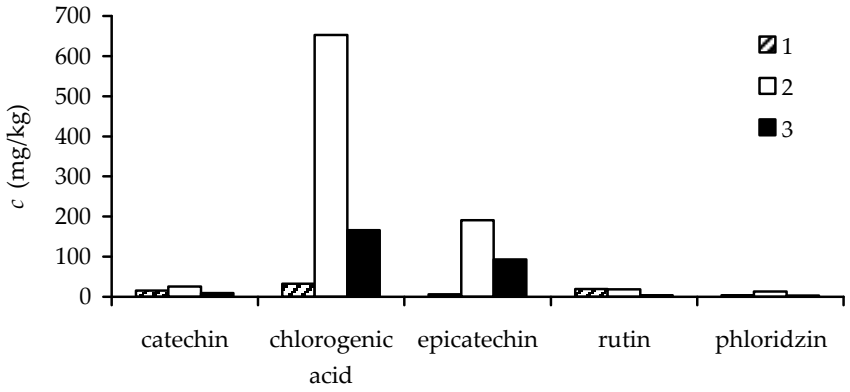

Figure 2. The content of phenolic compound in apple peel (variety Angold) on rotten zone of infected apple tissue (1), on healthy tissue surrounding the rotten zone (2) and on non-infected apple (3)

Table 3. Content of phenolic compounds in apple peel and pulp (mg/kg) in April

	Gala	Topaz	Angold	HL 704 A
Peel				
Catechin	39.66	15.29	33.81	38.27
Chlorogenic acid	159.34	160.31	116.99	254.54
Epicatechin	395.96	210.87	254.54	333.56
Caffeic acid	–	–	1.01	–
Rutin	35.38	26.69	13.31	20.30
Phloridzin	25.97	62.02	30.66	68.03
Pulp				
Catechin	13.74	11.32	9.14	25.03
Chlorogenic acid	172.50	183.94	166.32	33.72
Epicatechin	76.09	73.04	93.02	75.18
Caffeic acid	–	–	–	–
Rutin	2.51	2.09	3.96	4.05
Phloridzin	5.03	10.79	3.36	8.13

CONCLUSION

Increased phenolic are a good substrate for oxidative reactions. It is possible to speculate that this oxidative metabolism plays a role in counteracting the further development of fungus and that the resistance of some apple varieties against fungal diseases could be related to their ability to accumulate antifungal oxidation products after the infection [5]. The results obtained suggested that phloridzin and chlorogenic acid in combination with polyphenol oxidase activity could function to arrest infection associated with immature and ripening apple fruit [6].

Acknowledgements: The authors are grateful to the Research and Breeding Institute of Pomology Holovousy, Ltd., for the apple samples supplying and the Czech Science Foundation for financial support.

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