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THE PUNCTURE STRENGTH OF APPLE PEEL ACCORDING TO STORAGE CONDITIONS

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Summary. This article presents unique studies on apple peel (cv. Golden Delicious and cv. Ligol) strength after storage. The aim of the work was to estimate its puncture strength by measurements of the force value needed to puncture the peel. Measurements of peel strength were conducted by the use of specially designed peel holder. Peel thickness measurements were carried out by the aid of microscopic images and software. The studies showed that Golden Delicious apple peel was more susceptible to shelf-life conditions in contradiction to Ligol apples, where primary storage conditions (storage chamber) was the key factor in peel strength changes.

Key words: apples, peel, storage, strength, image analysis

INTRODUCTION

Peels of some fruits are a great disposal problem. For example, by-products of industrial mango processing may amount to 35-60% of the total fruit weight [Bernardini et al. 2003] By-products have been recently processed to prepare various chemicals [Habibi, Mahrouz, Vignon 2009] as cellulose microfibre in a stable, non-flocculating suspension. Fruit peel has potentially many different applications. Extract of the purple passion fruit peel has an antihypertensive effect [Zibadi et al. 2007]. While the studies of utilization of apple kernels as a source of antioxidants, starch, flour and food have been vast, there have only been scarce studies on peels.

The latest studies [Sun, Liu 2008] discovered that dietary modification, particularly an increased intake of fruits and vegetables has been consistently associated with reduced risk of various cancers. Apples are a major source of flavonoids and are characterized by antioxidant activity. He and Liu (2007) discovered that triterpenoids isolated from apple peels have potent antiproliferative activity and may be partially responsible for the anticancer activity of the whole apples. Triterpenoids show antiproliferative activity against human liver cancer, breast cancer and colon cancer.

Consumption of fruits and vegetables has been shown to be effective in the prevention of other chronic diseases. [Maneenuam 2007; Wolfe, Wu, Liu 2003]. Apples are commonly eaten and are large contributors of phenolic compounds in European and North American diets [Valle 1998; Funebo 2000]. 35% of deaths from cancer can be avoided by dietary modification [Acevedo 2008]. The content of polyphenolic compounds is particularly high in the peel, compared to flesh or cores of apples [Drogoudi et al. 2008]. The antioxidant activity, phenolic compound, variable sugar and acid content is strictly attributed to specific apple cultivar [Kuckenberg 2008].

Apple peel tissue plays a significant role in climacteric ethylene biosynthesis [Lara, Vendrell 2003]. Remarkable differences were observed in the regulation of ethylene biosynthesis in peel and pulp. Apple peel as well as whole fruit may have different characteristics due to conditions during ripening in an orchard, harvest conditions as well as storage time and method [Saltveit 2003; Rocha 2001; Ju, Curry 2002]. Storage disorders such as superficial scald can be effectively diminished [Whitaker 2000] for example by the use of diphenyloamine (DPA) as an anti-scald agent.

Limited commercial value occurs quite often during fruit ripening [Puchalski et al. 2007] and storage [Stropek, Gołacki 2008]. Chen et al (2009) reported that fruit is more often exposed to heat stress as it has higher surface temperature in the sun due to its limited cooling capacity via transpiration. If the fruit peel temperature reaches threshold, damage to the peel occurs. Fruit peel exposed to light during growth contained less simple phenols, more anthocyanin and developed less scald than peel from the shaded side [Ju et al. 1996]. The peel exposed to sun had higher activities of enzymatic and non-enzimatic antioxidants [Cheng, Ma 2003] Preharvest temperature also influences the scald susceptibility in apple peel [Thomai 1998]. If the recorded time prior to harvest was longer (on fruit exposed to t<10°C for 120-160h), superficial scald decreased to negligible values.

MATERIALS AND METHODS

A B

Fig. 1. Storage of apples: A-airtight door of ULO chamber, B-chest of apples before sealing

The objectives of the study were apples of two different cultivars: Golden Delicious and Ligol. After the harvest produce was placed in ULO chambers (Fig. 1.), they were sealed after being fully loaded.

Half of the sampled apples were placed in regular store. Total storage time was 150 days. Apples were sampled 5 times during storage in 30-days intervals excluding initial studies on fresh material. The strength of apple peel was measured just after taking out of the chamber and after 21 days of shelf-life at 6°C.

Apple peel removed from equator of the fruit was prepared to puncture test by gently removing the remains of apple flesh from the peel. Specimens were placed in the specially designed device (Fig. 2).

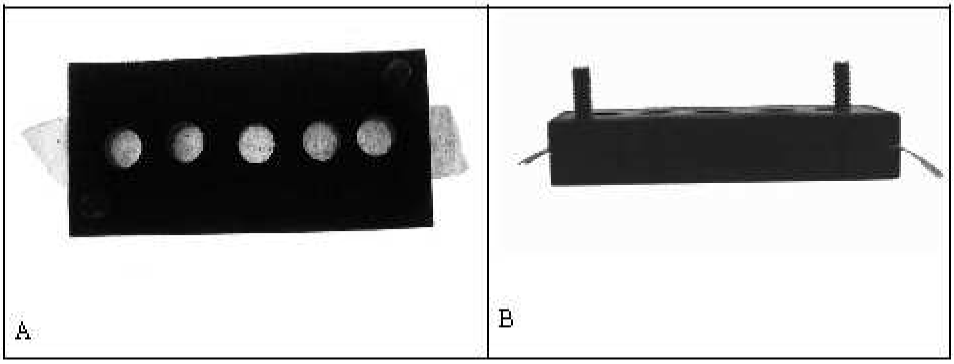

Fig. 2. Fastening device for puncture tests of the peel: A – upright view, B – horizontal view

Cylindrical-shaped probe was used to simulate the puncture of the peel by human's incisors. Testing speed was 500 mm/min. Tests were made by the use of Stable Microsystems texture apparatus and software. During the test the force needed to puncture the peel was recorded.

The thickness of the peel was measured by an optical microscope by the use of measuring software. Samples of the apple flesh (2mm cubes) including peel tissue were cut from equatorial zone of the apple. It was placed into the sequence of solutions including aldehydes, phosphate buffers, alcohols, xylene and paraphine as impregnating agent. Paraphine- impregnated specimens were cut off at 5μm slices to be observed and measured by the use of optical microscope (Fig. 3.).

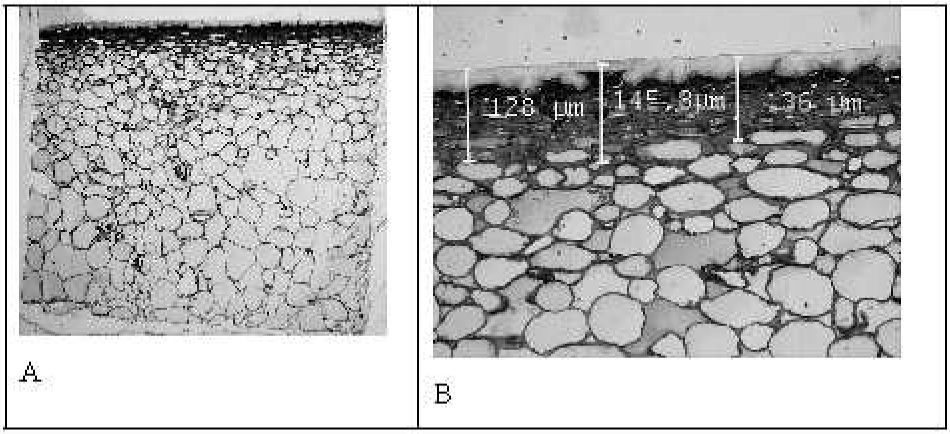

Fig. 3. Specimen images: A-overall view (magnification 40x),
B-measurement sectors (magnification 200x)

Measuring procedures were possible due to special software after calibration of the image (magnification 200x).

RESULTS

Results of the experiments were presented in fig. 4 to 7. They were given separately as results obtained from 1-st stage of the experiment (measurements done after sampling apples from the storage chambers – Variant A. The 2nd stage of the experiment took place after 21 days of shelf life at 6°C (Variant B).

Statistics were calculated by the use of Statistica 6.0 software. All the data were analyzed by ANOVA module (variance analysis) at α=0,05 importance level.

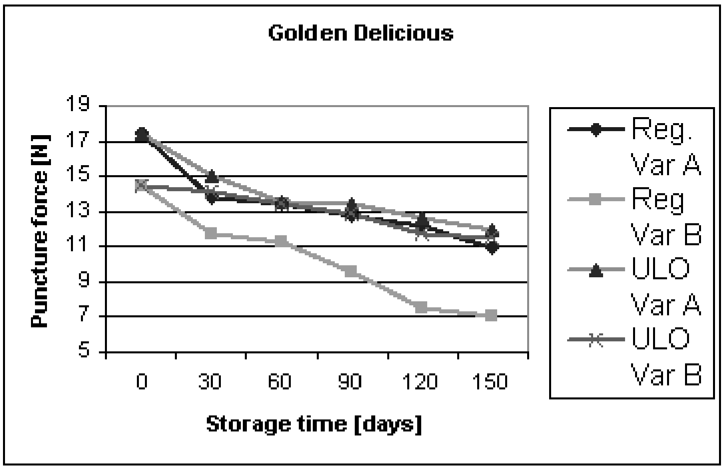

Fig. 4. Broad lines of storage conditions on peel strength in Golden Delicious apples

The first stage of the experiments (Variant A) has shown that the peel strength of Golden Delicious apples is independent from storage conditions. There were no important differences (α=0,05) between peel strength of the fruits stored in ULO and regular store (Fig 5).

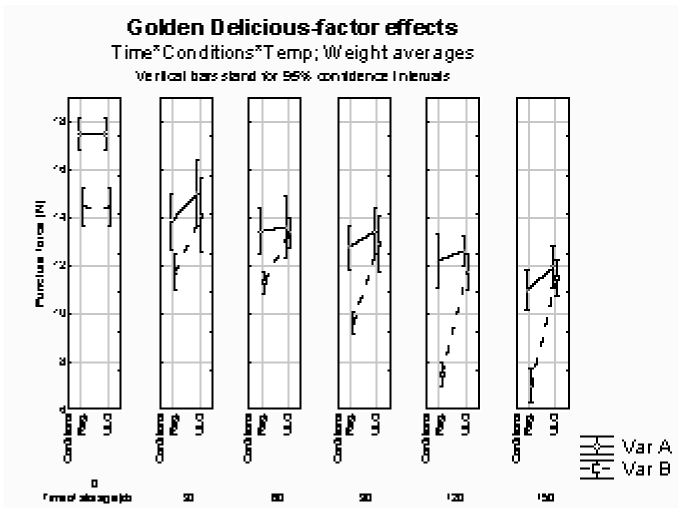

Fig. 5. Effect of storage on peel strength in Golden Delicious apples (variance analysis)

Prolonged shelf-life (Variant B) at regular atmosphere had no important differences to the fruits previously stored in ULO conditions. Though this variant of storage caused important collapse of peel puncture force for the apples sampled from regular store, this is distinctly perceptible only at the first stage of the experiment (for fresh fruits).

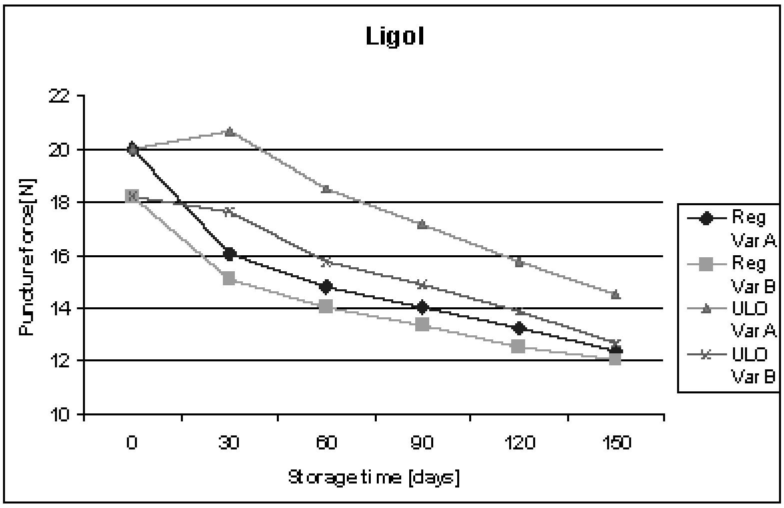

Fig. 6. Broad lines of storage conditions on peel strength in Ligol apples

The decline of peel strength observed in Ligol cultivar apples was also perceptible but it is very different from that in Golden Delicious. The conditions of storage (regular vs. ULO) strongly influenced the peel strength (Fig. 7).

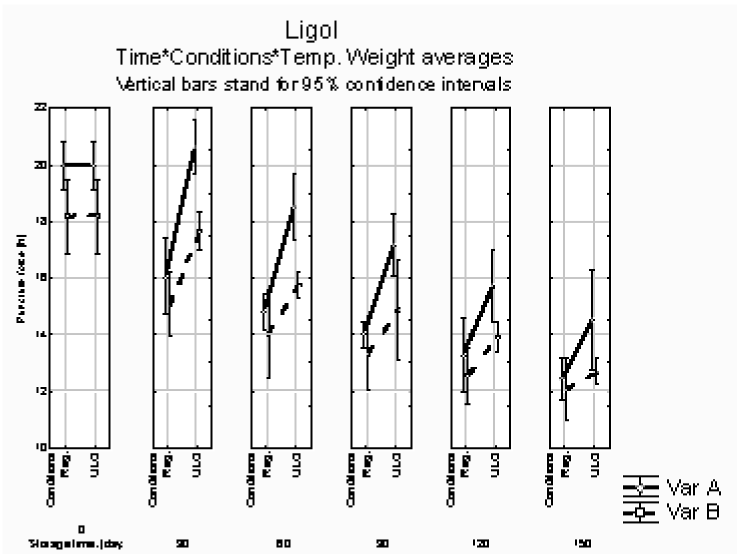

Fig. 7. Effect of storage on peel strength in Golden Delicious apples (variance analysis)

The difference between force needed to puncture the peel was significant in a majority of the tested samples and terms of storage. Subsequent storage in 6°C had no important influence on peel strength. This is peculiarly visible for the fruits sampled from the regular store chamber. Time of storage was an important factor for commodity alterations during storage in ULO conditions.

Table 1. Apple peel thickness observed through the storage period

Sample umber	Storage time [days]	Peel thickness [μm]	
		Golden Delicious	Ligol
1	0	119±12	158±18
2	30	125±11	160±17
3	60	122±10	171±16
4	90	117±12	165±15
5	120	121±13	164±14
6	150	118±12	162±12

Apple peel thickness measured in equatorial zone had no visible changes on all dates of experiment. Fruit peel after shelf life (Variant B) was more infirmed (α=0,05) only up to 60 days of storage. Subsequent storage had no influence on the peel strength decrease after shelf-life.

Divergence in apple fruit and peel changes were observed by Lara and Vendrall (2003). Ethylene biosynthesis in pulp and peel were remarkably different [Drogoudi, Michailidis, George, 2008]. Gas transfer and transpiration rates were of higher values for commodity stored in regular storage chambers. Fruits responses to different storage conditions were strictly associated with the properties of specific apple cultivars [Łata 2008; Wolfe, Wu , Liu R 2003]. To sum up, the effect of storage is strictly combined with numerous factors which also affect the peel strength.

CONCLUSIONS

Shelf-life after storage reduced the peel strength in the tested apples. The fruit of Ligol cultivar stored in ULO has more distinct changes after shelf-life. The peel strength of Golden Delicious apples declined only after regular storage.

Storage environment converted into shelf-life conditions decreased importantly (α=0,05) the peel strength of Ligol apples just only after 60 days of ULO storage. The decrease of peel strength in Golden Delicious apples was significant (α=0,05) thoroughout the storage period.

While the apple peel thickness can be regarded as constant, its strength changes are strictly connected with alterations in peel tissue caused by its modifications during storage in various conditions.

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WYTRZYMAŁOŚĆ SKÓRKI JABŁEK W ZALEŻNOŚCI OD WARUNKÓW PRZECHOWYWANIA

Streszczenie. Praca przedstawia próbę oceny zmian wytrzymałości skórki jabłek (Golden Delicious oraz Ligol) po przechowywaniu. Celem pracy było ustalenie przebiegu zmian wytrzymałości na przebicie skórki jabłek w zmiennych warunkach ich przechowywania. Pomiary wytrzymałości skórki przeprowadzono z użyciem skonstruowanego do tego celu specjalnego uchwytu. Pomiary grubości skórki wykonano z użyciem mikroskopu świetlnego wyposażonego w specjalne oprogramowanie. Wyniki badań wskazują, że skórka owoców jabłoni odmiany Golden Delicious była bardziej podatna na zmiany warunków po wyjęciu z komór przechowalniczych w odróżnieniu od odmiany Ligol, w której większe zmiany wytrzymałości skórki obserwowano podczas przechowywania w komorach (chłodnia lub ULO), których warunki były głównym czynnikiem tych zmian.

Słowa kluczowe: jabłka, skórka, przechowywania, wytrzymałość, analiza obrazu