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Evolution of biochemical and physical parameters of two fresh-cut fruits over storage at 4°C

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Biochemical and physical changes of two types of fresh-cut fruits packaged in plastic containers and stocked at 4°C were studied over a period of six days. The first type of container was film-lidded and contained orange juice, pomelo, kiwifruit and orange slices. The second type was plastic-lidded and contained orange juice, apple, kiwifruit and orange slices. Color, vitamin C and carbohydrates changes were investigated. In film-lidded containers, the results showed significant variations of brightness in kiwifruit and pomelo. Carbohydrates decreased in orange juice in plastic-lidded containers. Vitamin C content did not significantly change. These results suggest that carbohydrates oxidation could be prevented by vitamin C and low oxygen observed in containers atmosphere which avoids enzymatic browning in most fruits. Overall, these results indicate a relative good stability of nutrients and well preserved organoleptic qualities of these fresh-cut fruits during the storage.

Key words: Fresh-cut fruits, orange juice, carbohydrates, color, vitamin C.

INTRODUCTION

Fresh-cut fruits and vegetables uses fresh, uncooked, peeled, carved, without preservative and ready to eat fruits and vegetables (Watada and Qi, 1999). A minimal processing of the raw fruits and vegetables is needed to keep the freshness of these products as well as supply them in a convenient form that allows preserving their nutritional quality (Soliva-Fortuny et al., 2002). Processing of fresh-cut fruits and vegetables includes peeling, carving and other mechanical actions and can cause loss of physical and biochemical parameters such as color, texture, aroma and nutrients (Watada et al., 1990). Nevertheless, because of their freshness and high content of sugars, organic acids, vitamins and minerals, fresh-cut fruits and vegetables are considered as being more nutritious than canned and frozen foods (Klein, 1987). Fresh-cut fruits undergo a wounding stress in the cut tissues as a consequence of mechanical injury, leading to an increase in their respiration rate (Watada et

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al., 1996). Respiration oxidizes molecules such as carbohydrates and organic acids. Moreover, the destruction of fruit cellular compartments causes the oxidation of phenol compounds by polyphenol oxidase that leads to enzymatic browning. To extend their shelf life, defined as the time required for nutritional and physical parameters loss to an acceptable level, fresh-cut fruits and vegetables are generally packaged in film bags or containers which create a modified atmosphere within the package. Low atmosphere in oxygen and high carbon dioxide are used to extend the shelf life of these products, by reducing respiration and ethylene production (Yang and Hoffman, 1984). Because oxygen is needed for enzymatic browning reactions, atmosphere with low oxygen and high carbon dioxide levels can contribute to reduction of browning in fresh-cut fruits and vegetables. Further studies showed that atmosphere containing high carbon dioxide levels within the package could inhibit the biosynthesis of phenolic compounds (Ke and Saltveit, 1989).

Physiological and biochemical mechanisms, such as enzymatic browning that leads to appearance change and nutrients loss, generally limits fresh-cut fruits and vegetables nutritional quality and shelf life (Toivonen and Brummel, 2008). With the aim to study changes of appearance and nutrients contents of two kinds of fresh-cut fruits salads, we measured the color, pH, ascorbic acid (vitamin C) and carbohydrates content over a storage period of six days at 4°C.

MATERIALS AND METHODS

Fresh-cut fruits salads samples

Two types of fruit salads were packaged in plastic containers by the Covial firm (France). The first type contained slices of kiwifruit (France), orange (Navel, France), pomelo, orange juice and coated with a film lid. The second one was made of slices of kiwifruit, orange (Navel, France), apple (Granny Smith), orange juice and coated with a plastic lid. The containers weight was adjusted at 125 g by adding fresh orange juice during the preparation. They were then shipped by cool boxes at our laboratory. The marketing conditions of these products were recreated in the laboratory by stocking them at 4°C. Two experiments were carried out on each type of container. For each experiment, the slices of each type of fruits and juice from 10 film-lidded or from 8 plastic-lidded containers were mixed and analyzed to obtain daily measurements of parameters (color, pH, carbohydrates and vitamin C contents) over 6 days. In total, 120 film-lidded and 96 plastic-lidded containers were analyzed.

Determination of carbohydrates by high pressure liquid chromatography (HPLC) and pH measurements

Orange and pomelo slices were grinded. Kiwifruit and apple slices were first boiled in ethanol bath. After alcohol evaporation under vacuum at 37°C, kiwi and apple extracts were dissolved in water (20 and 50 ml for kiwifruit and apple, respectively) to obtain water-soluble extracts. The grinding of orange and pomelo, orange juice and water-soluble extracts of apple and kiwifruit were centrifuged at 10.000 rpm for 30 min. The supernatants were then filtrated through cellulose (Spartan 30/B, Schleicher and Schuell, 0.45 µm filter, 30 mm diameter). The filtrates (20 µL) were analyzed by HPLC. The HPLC system consisted of a LC-6A pump and a C-R5A Chromatopac data processor (Shimadzu, Japan) equipped with ions exchange column (temperature, 35°C) and a differential refractometer (Beckman 155, USA) that allowed detection of carbohydrates (sucrose, glucose and fructose). The column was eluted with sulfuric acid (8.10^{-2} N) with a flow rate of 0.4 $ml.min^{-1}$. The results were expressed in mg.100 g^{-1} of fruit fresh weight. The pH was measured on orange juice and fresh-cut fruits supernatants obtained as described above, using a pH meter (Schott, Germany).

Color analysis

Fruit slices and juice color was measured with a Minolta colorimeter CR200 (Minolta Corp., USA) using Hunter *L*, a*, b** scale (Hunter, 1958), where *L** is the brightness index; and the chromatic components *a** and *b** are the red-greenness and the blue-yellowness, respectively. The fruit slices were grinded and the color values (*L** and *a**) were immediately measured to limit modifications due to enzymatic browning.

Vitamin C (ascorbic acid) assay

Ascorbic acid concentration was determined on orange juice and fresh-cut fruits supernatants, obtained as described in carbohydrates assay section, by spectrophotometry at 525 nm as previously described (Delaporte and Macheix, 1968) using an UV-Vis spectrophotometer (Uvikon, Germany). The reaction is based on the reduction of dichlorophenol indophenol (DCPIP) by vitamin C in acid medium, in the presence of phenolphthalein. The results of vitamin C content were expressed in mg.100g^{-1} of fruit fresh weight.

Statistical analysis

The data show the daily values of each parameter (pH, vitamin C, sucrose, glucose, fructose and color) studied per experiment in fresh-cut fruits and orange juice, as described above. Differences in daily values were compared between the both film-lidded or plastic-lidded by using GraphPad Prism 6.0 (GraphPad Softwware, San Diego, CA), and subjected to ANOVA variance procedure. The Fischer least significant difference method was used to determine difference among means. A p value < 0.05 was considered statistically significant.

RESULTS

pH analysis

Overall, the pH fluctuations were measured between 3 and 3.5. Significant variations were found in slices of kiwifruit ($p<0.01$), orange ($p<0.05$) packaged in film-coated containers and in slices of apple ($p<0.05$) packaged in plastic-coated containers. In contrast, the pH did not significantly change in pomelo and orange juice whichever the type of container (Figure 1).

Vitamin C (ascorbic acid)

Vitamin C was determined by spectrophotometry at 525

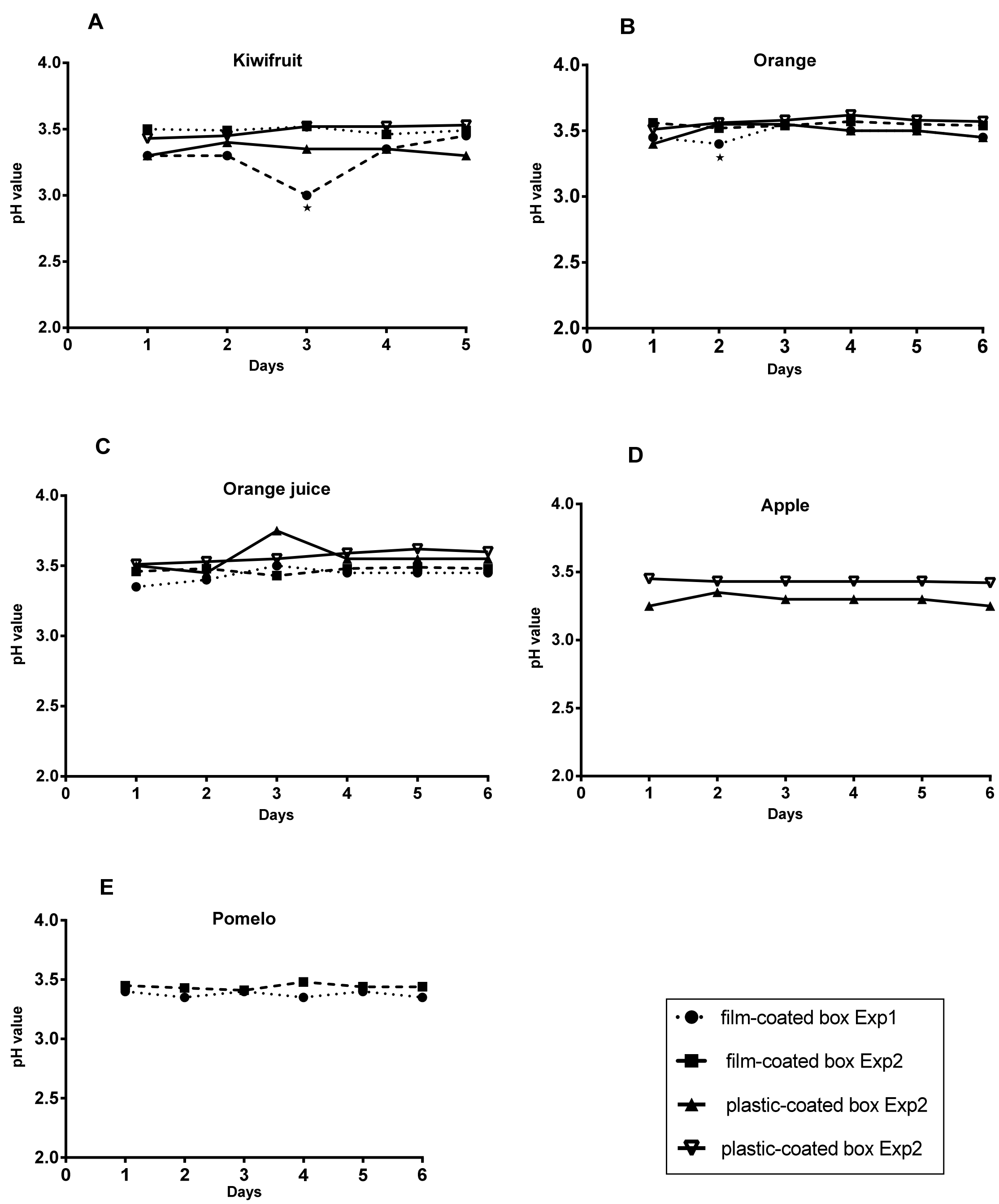

Figure 1. pH time variations measured in fresh-cut fruits and orange juice during storage.

nm and the content was expressed in mg.100 g^{-1} of fruit fresh weight. The results showed a slight but not significant loss of vitamin C in all the fresh-cut fruits and orange juice in both film-coated and plastic-coated containers (Figure 2).

Carbohydrates

The carbohydrates (sucrose, glucose and fructose) were obtained by HPLC and expressed in mg.100 g^{-1} fw. (Figures 3, 4 and 5, respectively). The results showed a significant decrease ($p<0.01$) of sucrose, glucose and fructose levels in orange juice packaged in plastic-coated containers from days 3 to 6 (Figures 3C, 4C and 5C, respectively); whereas the changes were not significant in orange juice packaged in film-coated containers. In contrast, carbohydrates content did not significantly vary in fresh-cut fruits in both film-coated and plastic-coated containers.

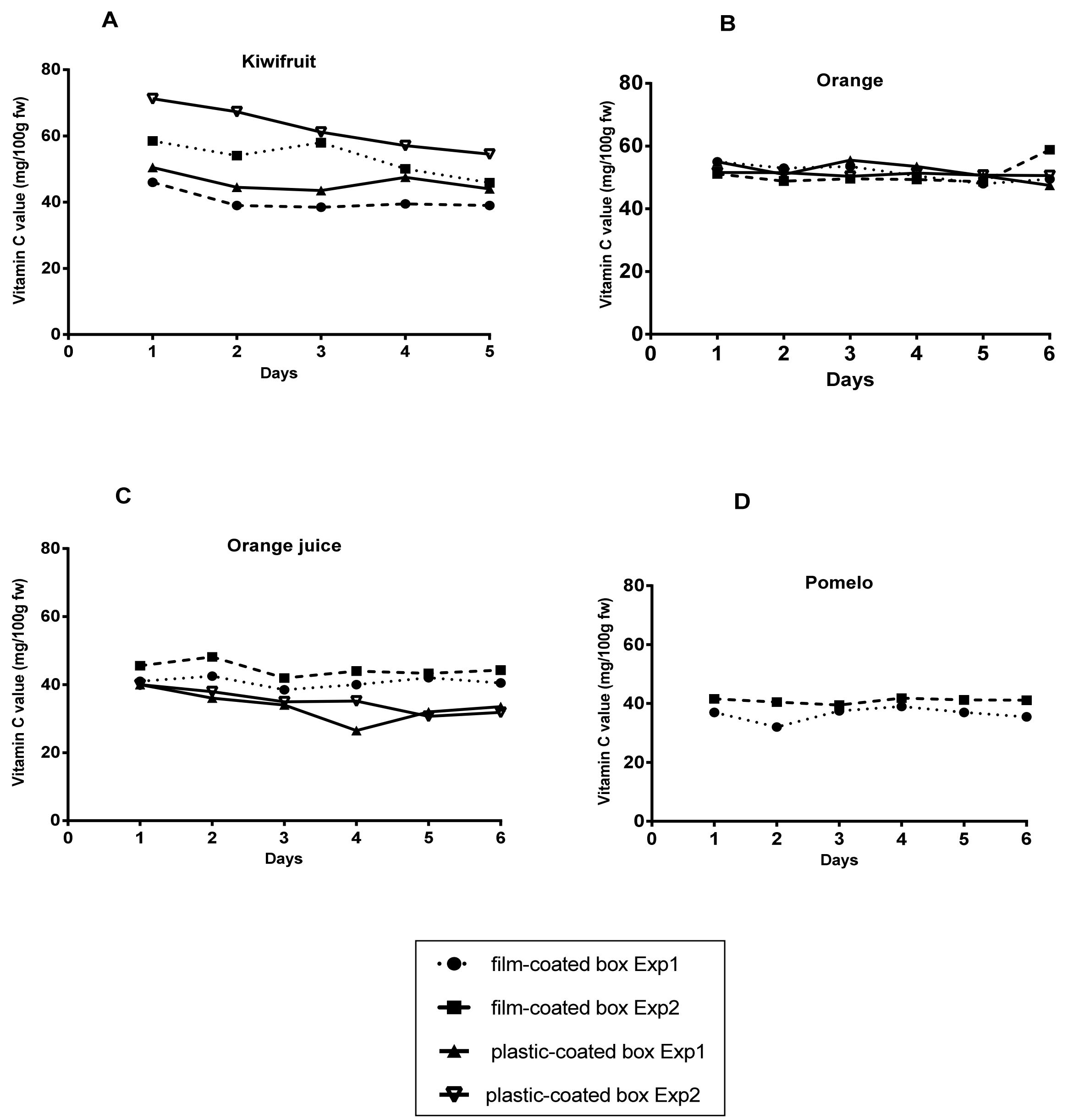

Figure 2. Vitamin C time variations in fresh-cut fruits and orange juice during storage.

Color analysis

Color measurements were performed using a colorimeter, based on *L*, a*,* and *b** color parameters. Except in film-coated containers (Figure 6A and D), where the brightness value (*L**) of kiwifruit and pomelo significantly changed (p<0.05), the chromatic component value (*a**) and brightness value (*L*)* did not significantly change in the other fresh-cut fruits slices and orange juice whichever the type of container (Figures 6 and 7).

DISCUSSION

In film-lidded containers, color variation was observed in the brightness (*L**) in kiwifruit and pomelo slices (p<0.05) whereas no change of color was observed in plastic-lidded containers. Color variation is due to enzymatic browning caused by the oxidation of phenolic compounds due to the effect of polyphenol oxidase. To avoid oxidation in these products and to extend their shelf life, low atmosphere in oxygen and high carbon dioxide are used to reduce respiration, which leads consequently to ethylene production (Yang and Hoffman, 1984). The color change in kiwifruit and pomelo observed in film-lidded containers could be suggested as a consequence of exposure of these fruits to atmospheric oxygen further to the breaking of the film lid over the transportation or storage. Such a hypothesis can be supported by our

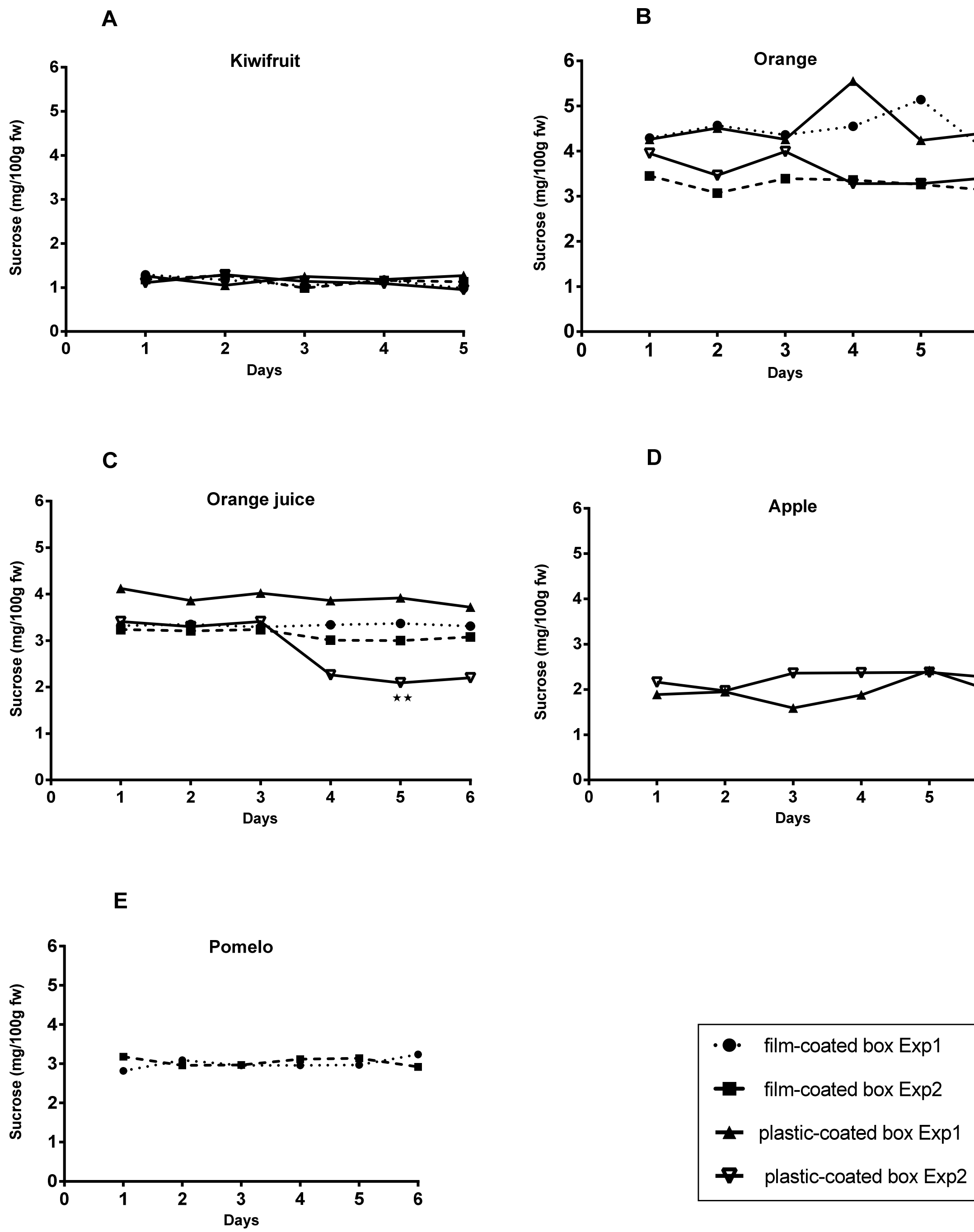

Figure 3. Sucrose time variation in fresh-cut fruits and orange juice during storage.

results obtained in plastic-lidded containers in which fruits color did not change. A low oxygen concentration in combination with moderate carbon dioxide rate is used to maintain the visual appearance of fresh-cut fruits (Agar et al., 1999). In fresh-cut apple such as Fuji apple variety, such an atmosphere combination cannot prevent enzymatic browning because of their high phenols content (Rojas-Graü et al., 2007, 2008). In contrast, in Granny Smith apple variety, the phenolic compounds have been reported to decrease during the development period and during a cold storage (Pérez-Ilzarbe et al., 1997). Our results agree with these previous studies since a slight but not significant color variation was observed in Granny Smith apple slices used in our study.

Ascorbic acid content did not significantly change in all fruit slices and orange juice in all the types of packaging.

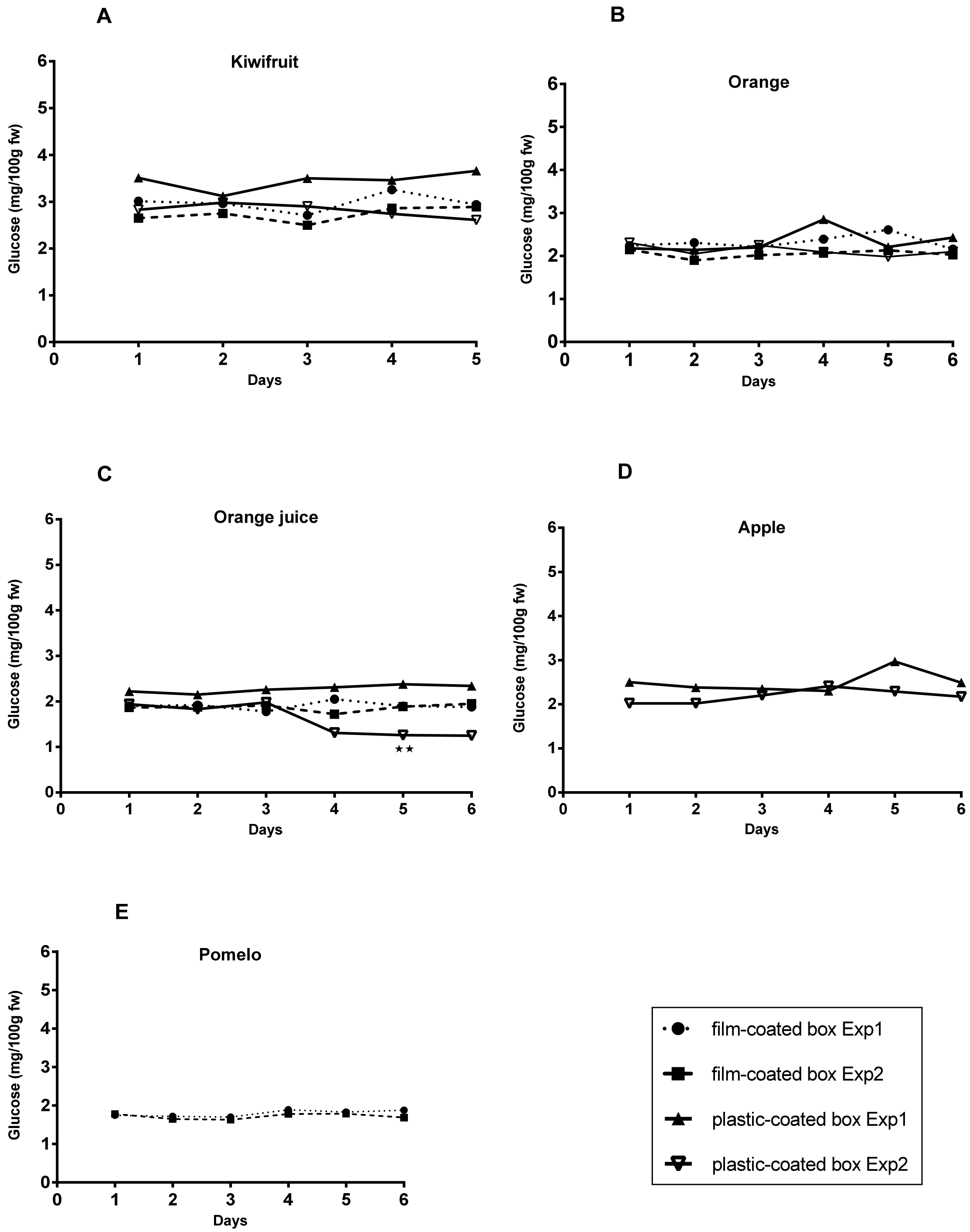

Figure 4. Glucose time variation in fresh-cut fruits and orange juice during storage.

These results agree with a previous study reported by Rivera-Lopez et al. (2005) showing that ascorbic acid content was significantly affected by temperature and storage period. Indeed, these authors observed that vitamin C content did not change in fresh-cut papaya slices stored at 5°C over 6 days but decreased at 10 and 20°C or after 18 days of storage at 5°C. We suggest that such a slight variation of ascorbic acid could be due to its renewal by a reducing system, as the glutathione, produced in the tissues is still alive over a short storage period. Other studies reported strong decrease of ascorbic acid levels in whole kiwifruit at the end of a long time of a cool storage (Tavarini et al., 2008) and a rapid decrease in fresh-cut fruits when compared with whole

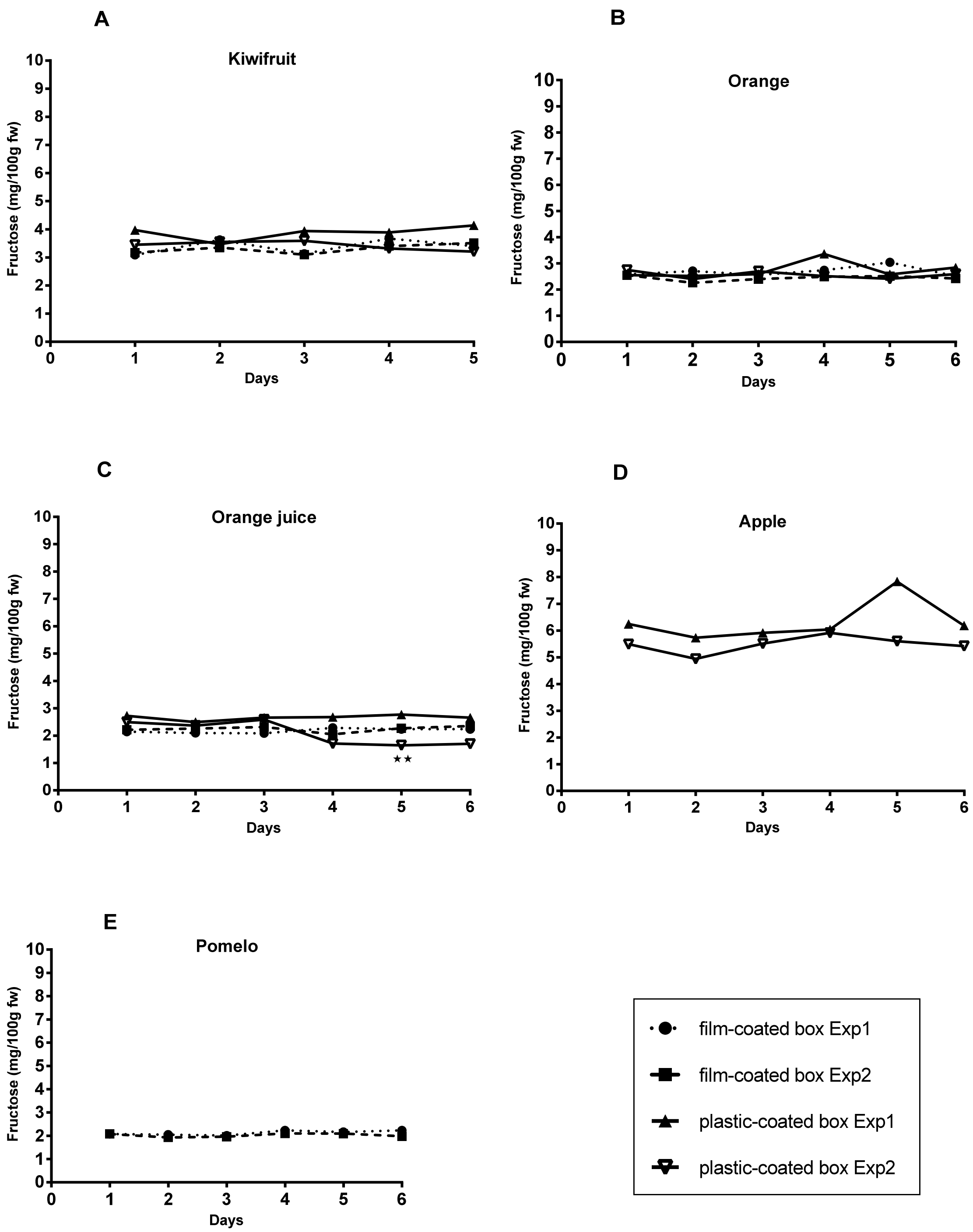

Figure 5. Fructose time variation in fresh-cut fruits and orange juice during storage.

fruits (Allong et al., 2000). In fresh-cut kiwifruit slices, a loss of 12% in vitamin C content was reported (Gil et al., 2006).

Loss of vitamin C content of about 22% has been also described in fresh-cut navel orange slices (Rocha et al., 1995) and in orange juice (Klimczak et al., 2007; Lee and Coates, 1999) over a long storage period. Such decreases of ascorbic acid could be caused by its use to avoid enzymatic browning by reducing quinones to phenolic compounds before they undergo reactions to produce pigments as previously described (Iyengar and McEvil, 1992).

The pH significantly changed in kiwifruit and orange slices in the film-lidded containers ($p<0.01$ and $p<0.05$,

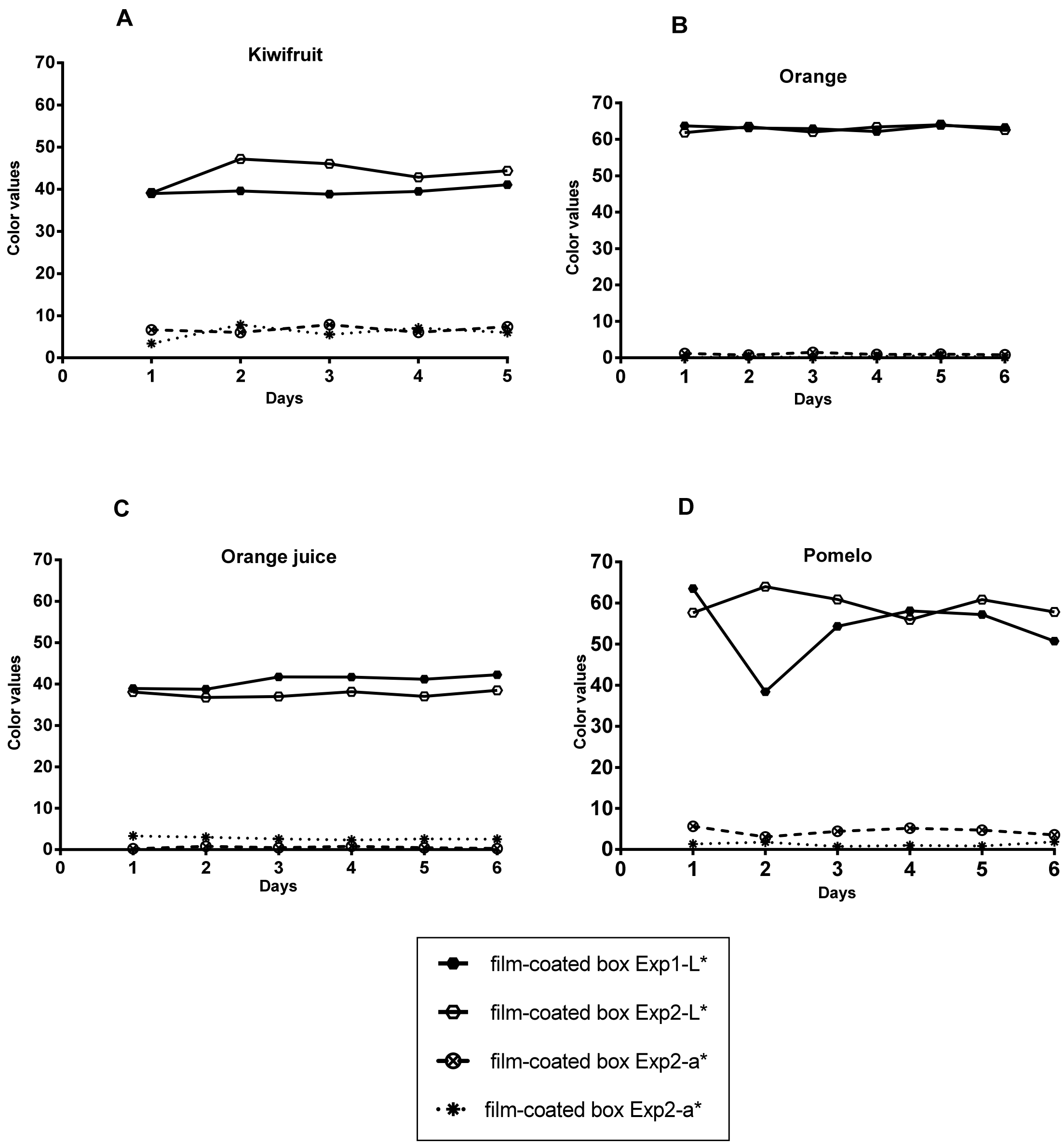

Figure 6. Color time variation (L* and a* values) of fresh-cut fruits in film-coated containers.

respectively) and apple slices in the plastic-lidded containers ($p<0.05$). In contrast, orange juice did not show any pH variation during the storage in all the types of package. Previous studies reported color changes in fresh-cut fruits induced by acidic pH of additives (Gomes et al., 2012, 2014). In our study, we used orange juice as a natural additive. The pH of orange juice varied between 3 and 3.5, and did not lead to fresh-cut fruits browning, as observed in plastic-lidded containers.

The carbohydrates content did not significantly change in the fresh-cut fruits slices, except in orange juice packaged in plastic-lidded containers where a significant loss ($p<0.01$) was found in sucrose, glucose and fructose content. The changes in glucose and fructose content could be associated with sucrose polymer degradation, as shown in previous studies (Soliva-Fortuny et al., 2004). In fresh-cut fruits, carbohydrates generally undergo oxidation as a consequence of mechanical injury of their tissues (Watada et al., 1996). In our study, the slight and not significant variations in sucrose, glucose and fructose levels observed in all fruit slices suggest low oxidation of carbohydrates during the storage of these fruits probably due to low oxygen and low temperature of storage which prevent or reduce enzymes activity. Such hypothesis is supported by respiration measurements that showed oxygen decrease followed by an increase production of carbon dioxide and ethylene rates (data not shown).

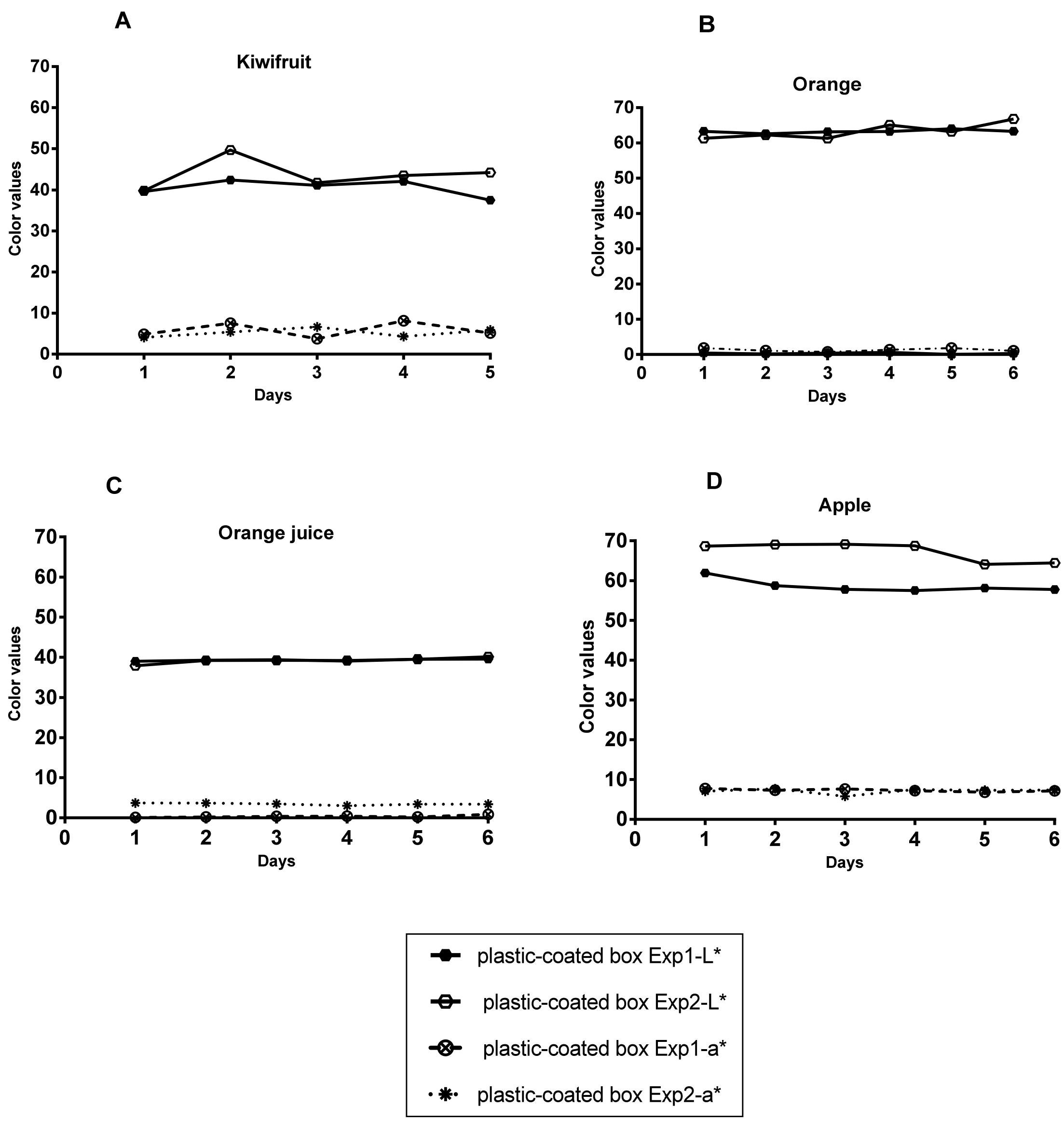

Figure 7. Color time variation (L* and a* values) of fresh-cut fruits in plastic-coated containers.

The obtained results indicate overall, a relative good stability of nutrients and well preserved organoleptic qualities of that fresh-cut fruits over the storage period.

Conflict of Interests

The author(s) have not declared any conflict of interests.

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REFERENCES

Agar IT, Massantini R, Hess-Pierce B, Kader AA (1999). Postharvest CO_2 and ethylene production and quality maintenance of fresh-cut kiwifruit slices. J. Food Sci. 64:433-440.

Allong R, Wickman LD, Mohammed M (2000). The effect of cultivar, fruit ripeness, storage temperature and duration on quality of fresh-cut mango. Acta Horticulturae 509:487-494.

Delaporte N, Macheix JJ (1968). Sur une méthode spectrophotométrique de dosage de l'acide ascorbique, de l'acide chlorogénique et des cathénines dans la pomme. Chimie Anal. 50 (4):187-198 (Article in French).

Gil MI, Aguayo E, Kader AA (2006). Quality changes and nutrient retention in fresh-cut versus whole fruits during storage. J. Agric.

Food Chem. 54 (12):4284-4296.
Gomes MH, Fundo JF, Poças MF, Almeida DPF (2012). Quality changes in fresh-cut 'Rocha' pear as affected by oxygen levels in modified atmosphere and the pH of antibrowning additive. Postharvest Biol. Technol. 74:62-70.
Gomes MH, Vieira T, Fundo JF, Almeida DPF (2014). Polyphenoloxidase activity and browning in fresh-cut 'Rocha' pear as affected by pH, phenolic substrates and antibrowning additives. Postharvest Biol. Technol. 91:32-38.
Hunter RS (1958). Photoelectric color difference meter. J. Opt. Soc. Am. 48:985-993.
Iyengar R, McEvil AJ (1992). Anti-browning agents alternatives to the use of sulfites in foods. Trends Food Sci. Technol. 3:60-64.
Ke D, Saltveit M (1989). Wounded-induced ethylene production, phenolic metabolism and susceptibility to russet spotting in iceberg lettuce. Physiology Plantarum 76:412-418.
Klein BP (1987). Nutritional consequences of minimal processing of fruits and vegetables. J. Food Qual. 10:179-193.
Klimczak I, Malecka M, Szlachta M, Gliszczynska-Swiglo A (2007). Effect of storage on the content of polyphenols, vitamin C and the antioxidant activity of orange juices. J. Food Compost. Anal. 20(3-4):313-322
Lee HS, Coates GA (1999). Vitamin C in frozen, fresh squeezed, unpasteurized, polyethylene-bottled orange juice: a storage study. Food Chem. 65 (2):165-168.
Pérez-Ilzarbe J, Hernàndez T, Estrella I, Vendrell M (1997). Cold storage of apples (cv. Granny Smith) and changes in phenolic compounds. Z Lebensm Unters Forsch A 204:52-55.
Rivera-Lopez J, Vazquez-Ortiz FA, Ayala-Zavala JF, Sotelo-Mundo RR, Gonzalez-Aguilar GA (2005). Cutting shape and storage temperature affect overall quality of fresh-cut papaya cv. 'Maradol'. J. Food Sci. 70 (7):482-489.
Rocha AMCN, Brochado CM, Kirby R, Morais AMMB (1995). Shelf-life of chilled cut orange determined by sensory quality. Food Control 6 (6):317-322.
Rojas-Graü MA, Grasa-Guillem R, Martin-Belloso O (2007). Quality changes in fresh-cut Fuji apple as affected by ripeness stage, antibrowning agents and stored atmosphere. J. Food Sci. 72:36-43.
Rojas-Graü MA, Soliva-Fortuny R, Martin-Belloso O (2008). Effect of natural antibrowning agents on color and related enzymes in fresh-cut Fuji apples as an alternative to the use of ascorbic acid. J. Food Sci. 73:267-272.
Soliva-Fortuny RC, Elez-Martinez P, Martin-Belloso O (2004). Microbiological and biochemical stability of fresh-cut apples preserved by modified atmosphere packaging. Innov. Food Sci. Emerg. Technol. 5:215-224.
Soliva-Fortuny RC, Oms-Oliu G, Martin-Belloso O (2002). Effects of ripeness stages on the storage atmosphere, color and textural properties of minimally processed apple slices. J. Food Sci. 67:1958-1963.
Tavarini S, Degl'Innocenti E, Remorini D, Massaï R, Guidi L (2008). Antioxidant capacity, ascorbic acid, total phenols and carotenoids changes during harvest and after storage of Hayward kiwifruit. Food Chem. 107(1):282-288.
Toivonen PMA, Brummell DA (2008). Biochemical bases of appearance and texture changes in fresh-cut fruit and vegetables. Postharvest Biol. Technol. 48:1-14.
Watada AE, Abe K, Yamauchi N (1990). Physiological activities of partially processed fruits and vegetables. Food Technol. 44:116-122.
Watada AE, Ko NP, Minott DA (1996). Factors affecting quality of fresh-cut horticultural products. Postharvest Biol. Technol. 9:115-125.
Watada AE, Qi L (1999). Quality of fresh-cut produce. Post Biol. Technol. 15:201-215.
Yang SF, Hoffman NE (1984). Ethylene biosynthesis and its regulation in higher plants. Annu. Rev. Plant Physiol. 35:155-189.