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Ripening Stage Effects on Mechanical and Functional Properties of Pastry Filled with Sweet Cherries (*Prunus avium*, 'Ferrovia' Cultivar)

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Abstract

Sweet cherry is a precious fruit for the wealth of minerals, vitamins and other important protecting, detoxifying and purifying principles. These features make it interesting in terms of nutritional and health point of view. Many studies have demonstrated the beneficial effects on prevention of cardiovascular and articular diseases, due to anti-inflammatory and analgesic action of sweet cherry. However, because of its seasonality, it needs technological treatments to be preserved (jam, puree or semi-finished products for pastry), that could compromise its nutritional quality. The aim of this work was to study the effects of ripening stage and technological tratments on mechanical and functional properties of pastries filled with sweet cherries during storage at room temperature. Results showed that the different ripeness of cherries influenced the mechanical properties of samples: pastries filled with overripe cherries resulted more hard (97 vs. 79 N), less cohesive (0.19 vs. 0.25) and springy (6.4 vs. 8.5 mm) than medium harvest cherries. The antioxidant capacity of medium harvest sweet cherries did not change after both technological treatments and storage (0.93 vs. 0.89 TEAC micromol/g dry basis). These results highlight the importance of ripening stage of processed fruit used as ingredient in complex food in order to obtain a product with good functional and quality properties.

Keywords: Sweet cherries; Ripening stage; Low fat filled pastries; Mechanical properties; Antioxidant activity

Introduction

One of the main nutritional problems today is the consumption of high quantities of fat and sugar, that has been associated with serious health problems. In the USA and Europe, daily fat consumption represents about 40% of total caloric intake; however, health specialists recommend that fats should not exceed 30% of total calories in a diet [1]. In fact, an excessive consumption of fats in general and saturated fatty acids in particular is known to be a major factor influencing the development of diseases such as coronary heart disease and obesity. On the other hand, the consumption of sucrose is considered as one of the factors that cause obesity and dental illnesses. Despite those problems, fat and sugar cannot be easily replaced, especially in a complex food system such as soft pastries, since they deeply influence the textural characteristics of those kinds of products. Fat provides flavour, mouth feel, appearance, palatability, texture and lubricity. Sucrose is one of the most important ingredients of bakery products, providing volume, texture and sweetness. Therefore, it is very difficult to replace or decrease those fundamental ingredients. Moreover, soft pastries are generally filled with creams with high content of sugars and fat rich in saturated fatty acids. Nevertheless, a wise solution that represents a right compromise between nutritional and sensorial characteristics could be a balancing of pastry recipe by decreasing the lipid fraction or replacing it with vegetable oil and substituting the sweet cream filling with minimally processed fruit. Hsin-Chia et al. [2] found that fruit and vegetable intake was inversely associated with risk of cardiovascular diseases. They also hypothesized that the protective role of fruit could be due to various nutrients such as fiber, vitamins and phytonutrients. Sweet cherry (*Prunus avium* L.) is one of the most appreciated fruit by consumer thanks to its excellent sensorial characteristics and its content of phenolics and anthocyanins that contribute to total antioxidant activity [3]. Sweet cherries are also thought to alleviate the pain associated with arthritis and gout [4]. They contain both hydrosoluble (C, B) and liposoluble (A, E and K) vitamins, carotenoids (in particular beta-carotene) and minerals such as calcium, magnesium, phosphorous and potassium [5].

Sweet cherries for fresh consumption are one of the most popular spring-summer fruits across the temperate regions of Europe. In numerous fruit production areas sweet cherries are also the first fresh fruits of the season [6]. Apulia thanks to its geographic position is the main Italian region for harvesting and commercializing of sweet cherries. In particular, 'Burlat' cultivar, that ripens early (between the second and the third decade of May), and 'Ferrovia' cultivar, that ripens medium-late (between the first and second decade of June) are the most diffused varieties [7].

Almost the whole production is addressed to fresh market even if a considerable percentage (15% EU production) is used to food industry. In particular, France, Italy and Spain are oriented towards the processing industry [8]. The main uses are canning (cherries in syrup and other products), preparations with alcohol (partly for the confectionery industry) and sugar-preservation (candied fruit, jam, etc.).

The quality of fresh fruit depends mainly on ripeness [9]. Fruit ripening is a complex process influenced by several factors. The changes in composition of sugars, organic acids and volatile compounds during ripening process play a key role in flavour development and can affect the chemical and sensorial characteristics (e.g., pH, total acidity, microbial stability, sweetness) of fruit. For this reason, many studies were carried out to evaluate the effects of ripening stage on quality of fresh sweet cherries [10]. Yet, scanty are the researches on the effects of ripening on processed sweet cherries. This subject is very important

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because of the significant chemical, physical and nutritional changes occurring during ripening that could make the standardization of the final product very difficult.

The aim of this work was to study an innovative pastry filled with partially osmo-dehydrated sweet cherries of 'Ferrovia' variety. In particular, the effects of ripening stage of sweet cherries on qualitative and functional characteristics of final product during storage were evaluated.

Materials and Methods

Raw materials

Sweet cherries 'Ferrovia' cultivar was supplied by Netti Lucia's farm (countryside Sammichele, Bari, Italy). Samples were picked from unique, 19 years old tree having a crop load of almost 40 kg, considering harvesting time referred to the date of commercial harvest for fresh consumption. There were two harvest dates: medium ripening harvest (at commercial harvest) and late harvest (5 days after commercial harvest). On each harvest date an approximately 2 kg sample of fruit was randomly collected. 1.5 kg of sweet cherries was osmo-dehydrated and the remaining the 0.5 kg was analysed.

Ingredients (wheat flour, sucrose, white eggs, maize starch, olive oil and baking powder, emulsifier and thickener) used to produce pastries were purchased on the local market.

Osmo-dehydration treatment

Stems were removed from fruits and, after washing, sweet cherries were blanched by microwave oven Samsung mod. CE 116KT (Milan, Italy) at 900 W for 330 sec. The blanching treatments were carried out dipping 500 g of sweet cherries into 1 L of distilled water. Then, they were cooled by running water, drained and dipped into an osmotic solution at 60 °Bx. The osmotic treatment was carried out stirring the solution with sweet cherries at room temperature for 150 min. After osmo-dehydration treatment, sweet cherries were washed by running water to remove the surplus of osmotic solution and gently blotted by paper. The partially osmo-dehydrated sweet cherries were packed in plastic bags and stored at + 4°C before utilization.

Filled pastries production

Pastries were prepared by blending all ingredients by kneading mod. KJ-1302 Kennex (Sesto Fiorentino – FI, Italy) in order to obtain sponge dough that was put into muffin mould with capacity of 50 mL. Each mould contained 28 g of dough and 6 g of sweet cherries. Half of the samples were prepared using medium ripening harvest sweet cherries and the others with late harvest sweet cherries. All samples were baked at 180°C for 20 min by convection oven Hot-Point ARISTON CP97SE2/HA INOX (Fabriano, Italy). Then, samples were cooled, packed into plastics (PET12 – PP/EVOH/PP60) bags (5 sample each bag) and stored at room temperature for 85 days. Two bags for each ripening stage were taken every 17 days to evaluate the chemical and mechanical characteristics changes of samples during storage.

Analyses

Physical, chemical and functional characteristics were evaluated on sweet cherries and/or pastries. In particular, the following analyses were carried out: pH, soluble solids, moisture, water activity, mechanical properties and antioxidant activity. All analyses were replicated at least three times.

pH determination

40 mL of distilled water were added to 10 mL of fresh juice or osmo-dehydrates samples (ratio 1:4 v/v) and homogenised for 1 min. The pH was measured using a pH meter Crison (mod. Meter_Basic 20, Spain) at 25°C.

Soluble solids content

Blanched sweet cherries and osmotic solution were analysed through a refractometer Abbe (Irymen Sistem-TYPE WYA 2s, USA). All tests were carried out at room temperature (25°C).

Moisture content (%)

Samples were placed in oven ISCO Model NSV 9090 (Italy) at 105°C up to constant weight [11].

Water activity determination:

Water activity values of osmo-dehydrated sweet cherries were measured by a hygrometer AQUALAB CX-2 (Decagon, Device, USA).

Mechanical properties

Texture Profile Analysis (TPA) was determined by an Instron 3343 universal testing machine (Instron Ltd., High Wycombe, UK) using a modified compression device that avoided transversal elongation of the samples. Each sample underwent 2 cycles of 30% compression. Analyses were carried out at room temperature and the cylindrical probe was moved with a constant speed of 127 mm/min. The determined variables were hardness (maximum force required to compress the sample), cohesiveness (A2/A1, where A1 was the total energy required for the first compression and A2 was the total energy required for the second compression) and springiness (ability of the sample to recover to its original shape after the deforming force was removed). Five replicates were performed for each sample.

Determination of antioxidant capacity

Antioxidant capacity was determined by scavenging of the radical 2,2-diphenyl-1-picrylhydrazyl (DPPH) [12, 13]. Stock solution was prepared by stirring 24 mg DPPH in 100 mL of methanol overnight. Trolox (6-hydroxy-2,5,7,8-tetramethylchromane-2-carboxylic acid) purchased from Fluka Chemie GmbH (Buchs, Switzerland) was used as standard and methanol as blank. Sweet cherries samples of 5 g were homogenised with 20 mL antioxidant extraction solution (prepared mixing 200 mL distilled water, 800 mL methanol and 84 mg sodium flouride 2 mM) for 5 min and filtered on filter paper with porosity ranged between 10-20 µm (Whatmann # 1). In the assay, 0.01 mL extract, standard (125, 250, 500, 1000, 2000, 2500, 5000 µM Trolox) or blank (methanol) and 0.99 mL DPPH solution were mixed. The absorbance of samples, standards and blank was determined after 5 min at 517 nm by a spectrophotometer UV/Vis (Pelkinelmer lambda 25, Milan, Italy). The percentage of the remaining DPPH was proportional to the antioxidant concentration, calculated as antioxidant capacity of Trolox and expressed as micromolar Trolox Equivalent Antioxidant Capacity (TEAC) per gram of dried matter.

Statistical Analysis

The two-way analysis of variance (ANOVA) test was carried out to evaluate the effects of ripening stage and storage time on results of considered analytical indexes by software StatSoft ver. 6.0 (Statsoft, Tulsa, USA). The means of these results were compared by the Fisher's test.

Results and Discussion

Blanching and osmo-dehydration treatments were carried out on fresh sweet cherries in order to preserve their quality and functional properties.

Figure 1 shows the Total Soluble Solids (TSS) of blanched sweet cherries and osmotic solution at different treatment times. Blanched sweet cherries show an increase of TSS during osmotic treatment while TSS values of osmotic solution decreased after 1 hour of treatment because of the water loss of sweet cherries and the migration of solids into fruits. Treatment times more than 150 min were not suitable because of the excessive loss of red colour of fruits and the slowing down of dehydration of sweet cherries (data not shown).

Results of water activity (aw) of samples at both ripening stages show a significant decrease after osmo-dehydration treatment confirming its effectiveness (Figure 2). The same trend was observed for pH values of blanched sweet cherries that increase with increasing harvest time also after osmotic treatment (Figure 2). Those results may be due to the loss of organic acids of fruit because of the normal physiological processes that occurred during ripening [14] and the leaching in the osmotic solution.

Figure 3 shows moisture values of sweet cherries used to fill pastries (after blanching, osmo-dehydration and baking treatments) as a function of storage time. Moisture of samples decreases very quick in the first 15 days and slowing down up to the end of storage. This trend was observed for both ripening stages. Moreover, variance analysis results show a significant effect of both storage time and ripening stages (Table 1). In fact, the moisture values of sweet cherries late harvest result lower than that harvest at medium ripening stage, afterwards baking and for all storage time (Figure 3).

Data of water activity are in agreement with results of moisture content (Figure 4 and Table 1).

These trends could be explained taking into account the moisture migration between pastry components (crust, crumb and sweet cherries) and the atmosphere of package. The moisture transport is more complex and difficult to analyse in food such as sponge cake. In this porous product, in fact, different mechanisms of moisture transport at microstructural level occur. An example is the translocation and

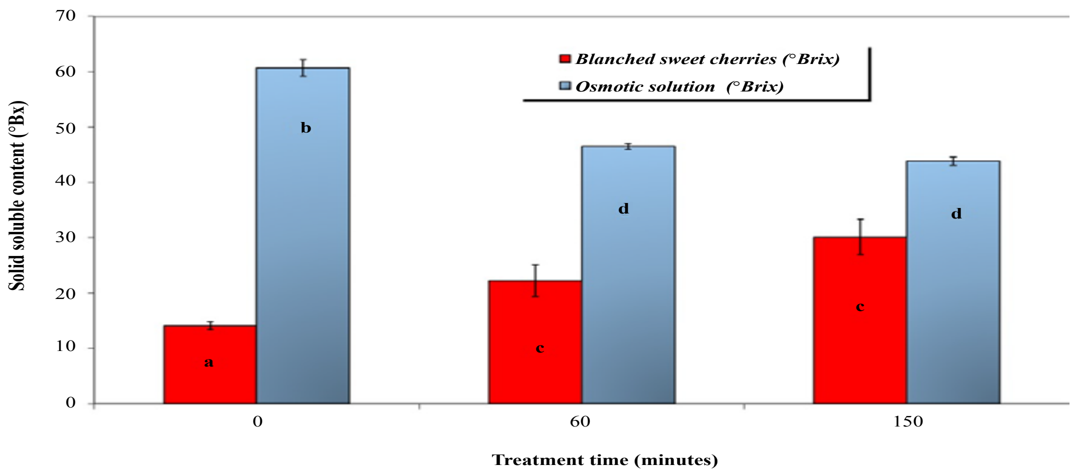

Figure 1: Values of soluble solid content (°Brix) of blanched sweet cherries and osmotic solution at different treatment times.

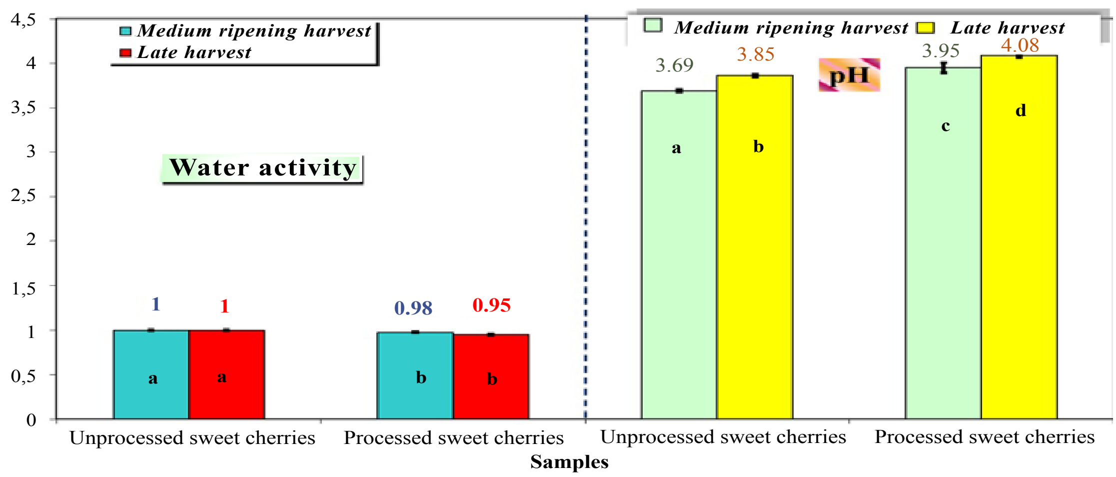

Figure 2: Values of water activity and pH of unprocessed and processed sweet cherries harvested at different ripening stages.

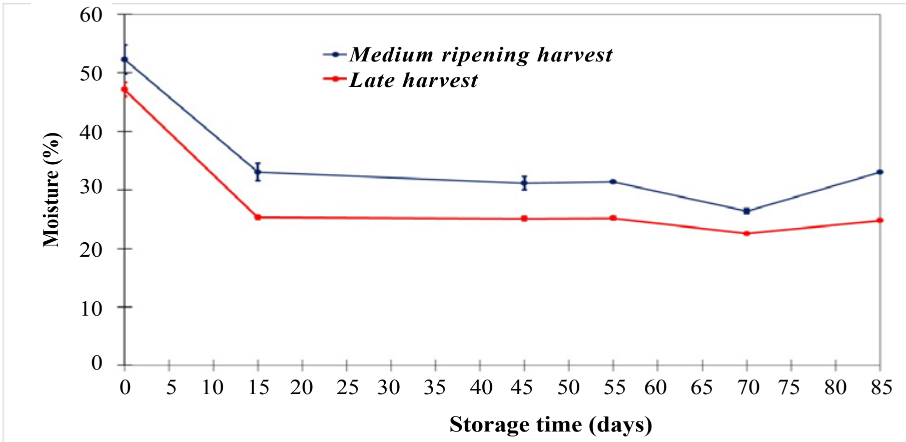

Figure 3: Values of water activity and pH of unprocessed and processed sweet cherries harvested at different ripening stages.

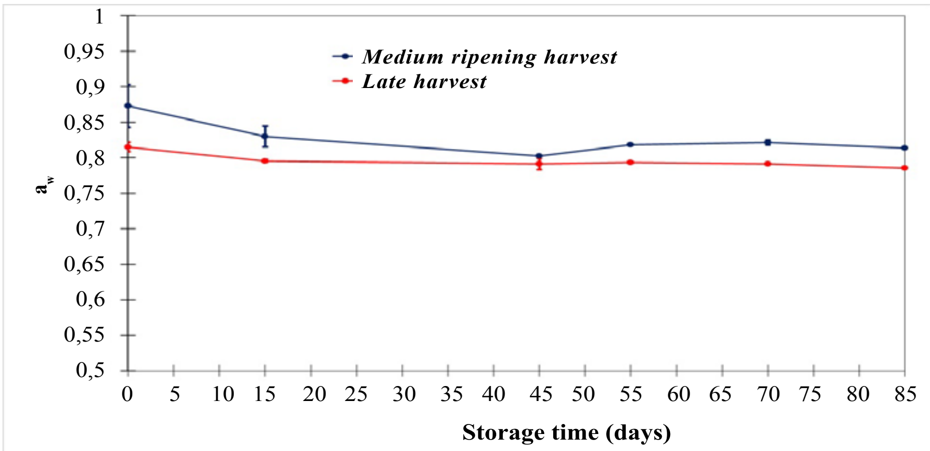

Figure 4: Water activity values of sweet cherries of both ripening stage used to fill pastries as a function of storage time.

the liquids diffusion as result of capillary action and concentration gradient [15]. It is possible to assume, therefore, that the decrease of moisture content and aw values of sweet cherries after 15 days of storage could be due to the migration of water from the cherries to the crumb and crust that show values of these indexes less than fruit filling. The lower moisture content and aw values of the late harvest sweet cherries in comparison with those harvest at medium ripening stage may be due to a greater and quickly dehydration of fruit during baking. This phenomenon was probably caused by structural changes of fruit during ripening, such as the loss of fruit firmness, changes in cell wall components and their enzymatic breakdown [16]. In cherry fruit, knowledge about cell wall breakdown remains meager. Davignon [17] reported the increase of total pectins during ripening, but he did not characterize pectic fractions and their neutral associated sugars. This characterization was performed by Barbier and Thibault [18], but was confined to the ripe stage of the fruit. Fils-Lycaon and Buret [19] found that the changes occurring during fruit development gave prominence to three physiological stages and suggested the progressive degradation of the middle lamella and primary cell wall. The firmness measurement was related to the equilibrium between the relative parts of these pectic fractions.

Figures 5-7 show the mechanical properties of pastries filled with sweet cherries harvest at both ripening stage as a function of storage time. Variance analysis results indicated a significant effect of storage time and ripening stage on all mechanical Properties (Table 1).

In particular, an increase of hardness and a decrease of cohesiveness of samples filled with sweet cherries harvest at medium and late ripening stage were observed during storage (Figures 5 and 6). These changes were more pronounced in samples filled with sweet cherries late harvest. On the contrary, a decrease of springiness during storage was found only for pastries filled with sweet cherries late harvest (Figure 7). The loss of softness of products during storage could be due to retro gradation of starch and glass transition of proteins and other constituents caused by the moisture loss. For the same reason these changes were more pronounced in products filled with sweet cherries late harvest.

The antioxidant activity of fresh, processed and stored sweet cherries harvest at different ripening stages and used to fill pastries was evaluated (Figure 8). The antioxidant activity of sweet cherries harvest at medium ripening stage did not show any significant decrease. A different behavior was observed for samples produced with sweet

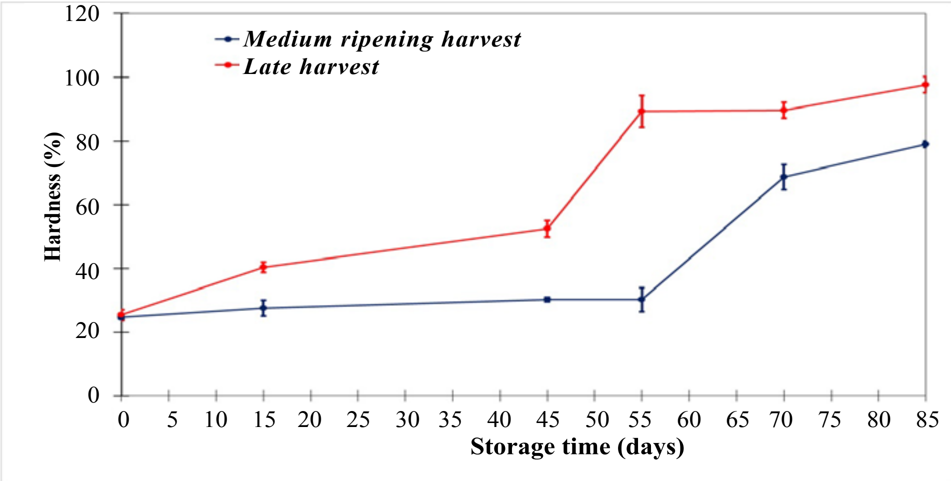

Figure 5: Hardness (N) of pastries filled with sweet cherries of both ripening stage as a function of storage time.

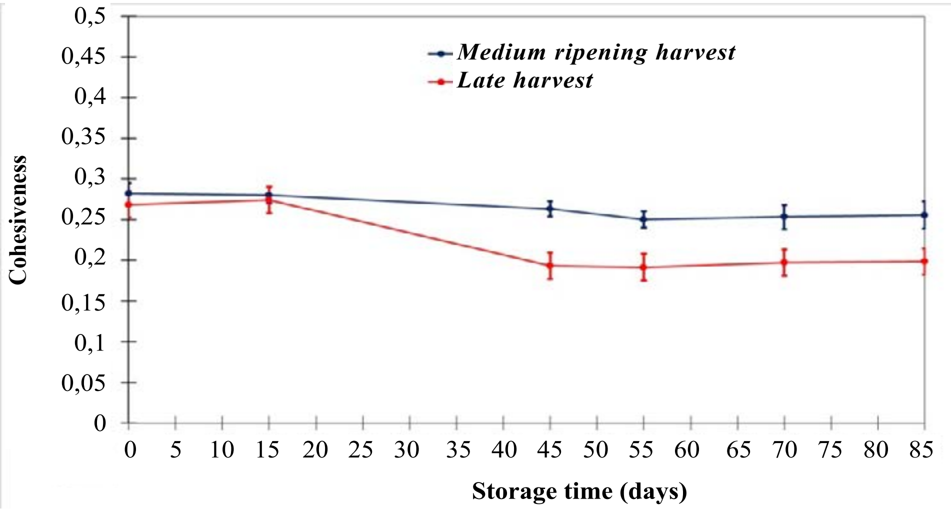

Figure 6: Cohesiveness of pastries filled with sweet cherries of both ripening stage as a function of storage time.

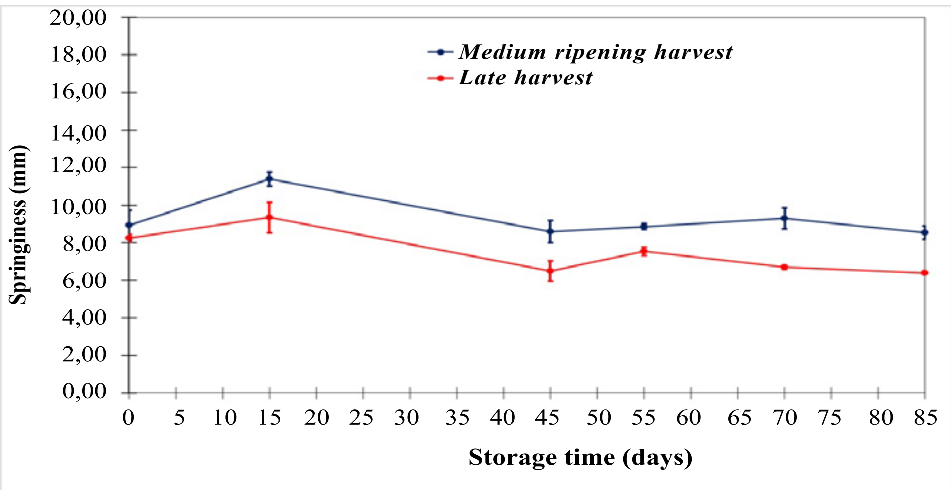

Figure 7: Springiness (mm) of pastries filled with sweet cherries of both ripening stage as a function of storage time.

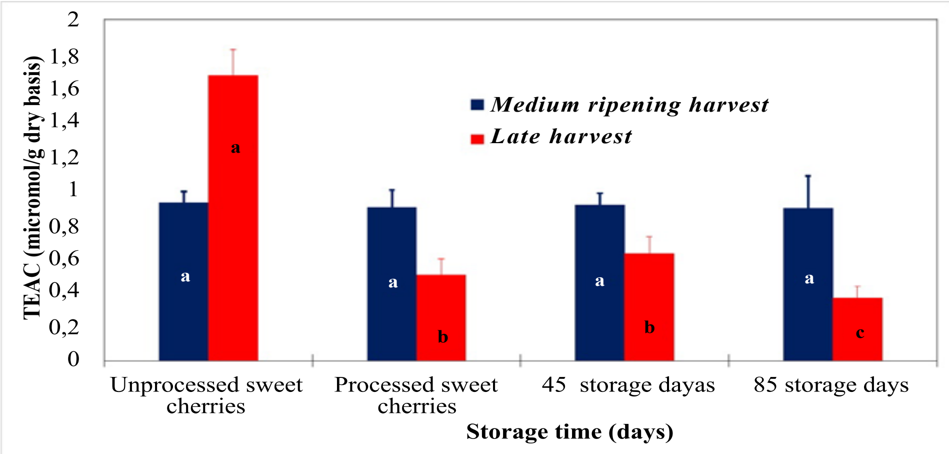

Figure 8: Antioxidant activity of fresh, processed and stored sweet cherries harvest at different ripening stages and used to fill pastries.

Analytical index	Effects	Error	MS	F	p-level
Moisture content	Intercept	1.47	23733.43	16130.71	0.01*
	Storage time		332.26	225.82	0.01
	Ripening stage		230.76	156.84	0.01
aw	Intercept	0.01	23.66	85056.13	0.01
	Storage time		0.01	6.35	0.01
	Ripening stage		0.01	9.69	0.01
Hardness	Intercept	166.5	107166.8	643.74	0.01
	Storage time		3899.4	23.42	0.01
	Ripening stage		1466.9	8.81	0.01
Cohesiveness	Intercept	0.01	2.42	12597.68	0.01
	Storage time		0.01	14.83	0.01
	Ripening stage		0.01	5.03	0.01
Springiness	Intercept	0.64	2518.20	3938.25	0.01
	Storage time		6.84	10.70	0.01
	Ripening stage		10.35	16.19	0.01

*significant variable effect (p-level < 0.05)

Table 1: Variance analysis of chemical and mechanical results of pastries filled with osmo-dehydrated sweet cherries.

cherries late harvest. First, the antioxidant capacity of fresh sweet cherries late harvest was higher than sweet cherries harvest at medium ripening stages. These data are in agreement with Serrano et al. [20], who found a decrease of total antioxidant activity at early stages of ripening followed by an increase during medium ripening stage up to over ripening. After blanching, osmo-dehydration, baking treatment and storage, a remarkable decrease of antioxidant activity was observed for sweet cherries late harvest, suggesting the occurrence of changes in antioxidant compounds that are less resistant to thermal treatments and continue to degrade during storage. Since there are not finding on this subject in literature, it would be appropriate to identify the classes of antioxidant compounds starting from the fresh fruit and investigate how they degrade during processing and storage.

Conclusion

Results of this research show the importance of sweet cherries ripening stage for not only fresh consumption but also when this fruit is processed for industrial use. In fact, overripe cherries should not be used to produce filling for pastry particularly if packaging is not planned, because of the greater dehydration during cooking and storage that involves the product's mechanical properties falling off. The significant decrease of antioxidant capacity observed in late harvest sweet cherries after technological treatment and storage could compromise the functional properties of final product.

Finally, these results highlight the importance of ripening stage of processed fruit used as ingredient in complex food in order to obtain a product with good quality and functional properties.

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