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Quality evaluation on processed melons (*Cucumis melo* L.) packaged in protective atmosphere

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Abstract: In the last years the interest in the minimally processed horticultural products has increased because of the elevated level of convenience that they assure and for their organoleptical and functional characteristics that are very close to those of fresh products. This research was finalized to the production of pre-sliced melons packaged in protective atmosphere. In particular, the comparison between the behaviour of two different cultivars (Harper and Proteo) was monitored for 10 days, by studying the effect of the composition of four different gaseous mixtures on the qualitative characteristics of the products (microbiological quality, relative humidity, colour, firmness and chemical parameters), selecting in this way the cultivar with the greater attitude to the packaging.

Key words: fresh cut melon, protective atmosphere packaging, shelf life

تقييم جودة الشمام (*Cucumis melo* L.) المجهز والمعبأ في وسط غازي وقائي

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الملخص:في السنوات الأخيرة زاد الاهتمام بالمنتجات البستانية المجهزة تجهيزا محدودا وذلك لسهولة تحضيرها ومشابهتها للمنتجات الطازجة في الصفات الحسية والخواص الوظيفية. في هذا البحث تم إنتاج شرائح الشمام وتعبئتها في وسط غازي واقي. على وجه الخصوص، تم المقارنة بين سلوك اثنين من أصناف الشمام (Harper and Proteo) عند تخزينها لمدة ١٠ أيام ودراسة أثر الوسط المكون من خلط أربعة من الغازات المختلفة على الخصائص النوعية للمنتجات (الجودة الميكروبيولوجية، والرطوبة النسبية، واللون والقوام والصفات الكيميائية). وبذلك تم بهده الطريقة اختيار الصنف المتوافق أو الأكثر ملائمة مع التعبئة والتغليف.

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Introduction

Vegetables, as all the biological systems, suffer of the qualitative decay either due to physical and biological processes or due to the interactions with the surrounding atmosphere. A lot of food technology processes have the aim to stabilize a product (drying, pasteurization, sterilization, packaging etc.) for conferring it a commercial life (shelf life) adapted for the market demand.

Recently, the market demand for minimally processed fruits and vegetables has undergone an important rise because of busy lifestyles, increasing purchasing power and increasingly health-conscious consumers (Corbo et al., 2006).

These products are composed by fresh horticultural commodities that, after the washing and the cutting operations, are packaged in bags or in trays and sold for being eaten immediately or after cooking. Processing of fresh-cut fruits involves wounding stress as a result of mechanical injury when peeling or cutting, leading to an increase in the respiration rates of fresh-cut commodities in comparison to those of the corresponding whole fruits (Watada et al., 1996). Minimal processing damages the tissue integrity, leading to several biochemical deteriorations, such as browning, off-flavors, texture breakdown, and to an increase in the possibility of microbial growth. Many factors may affect the physiological response of the fruit, including the cultivar, maturity stage, temperatures or packaging atmospheres (Oms-Oliu e al., 2007).

The package plays a fundamental role in preserving products from external agents whom could accelerate their qualitative decay. Coupling to the packaging in suitable plastic films or in rigid containers the refrigeration storage, is possible to obtain a slowing down of the deterioration processes due to the senescence phenomena and to the development of microorganisms that alter the qualitative characteristics of the fresh product (Piergiovanni, 1997; Chonhenchob, 2007).

During the storage, moreover, these products continue to breathe consuming oxygen, producing carbon dioxide, freeing heat. The exclusion of oxygen from the protective atmosphere introduced in the package, or its remarkable reduction, and eventually an increment of the carbon dioxide, allows extending the shelf life, regarding the not transformed product, and the maintenance over the time of its global qualitative characteristics (Kader and Watkins, 2000).

In this way the package, besides protecting hygienically the product and limiting the dehydration and the phenomena of senescence, contributes to slow down the respiratory activity and to limit the undesired reactions. In general, these objectives can be reached by using protective atmospheres with low concentrations of oxygen, carbon dioxide levels until 20% and the refrigeration in the post-packaging phase.

This typology of products keep, therefore, high qualitative characteristics, in particular freshness, hygienic-sanitary, organoleptical and nutritional, and allows one a remarkable time reduction for meal preparation and a smaller production of domestic wastes (Piergiovanni, 2001).

Efforts to improve the shelf-life and microbiological quality of fresh-cut melons have focused on raw material quality and ripeness (López-Gálvez et al., 1996), reduction of microbial populations on the melon rind by treatment with hypochlorite or hydrogen peroxide vapour (Ayhan and Chism, 1998), rigorous attention to sanitation during cutting treatment of cut melon with $CaCl_2$ or hypochlorite, controlled atmosphere storage (Portela and Cantwell, 1998), and storage at low temperatures.

Treatment of fresh-cut cantaloupe with 200 mg/l Cl_2 reduced aerobic plate counts by less than 1 log and did not appreciably delay visible spoilage (Sapers and Simmons, 1998). They have demonstrated that washing with dilute hydrogen peroxide (H_2O_2) solution is a highly effective sanitizing treatment for fresh apples (Sapers et al., 1999, 2000) and fresh-cut cantaloupe (Sapers et al., 2001).

Aim of the present work was to search parameters and methods suitable for extending the shelf life of melon slices packaged and ready to use; to compare the packaging attitude of two different cultivars of melon (Harper and Proteo) and to verify the chemical-physical variations during the storage in plastic films.

The choice of melon as fruit to treated and analyse is due to its considerable production and consumption both in Italy and all around the world, to its nutritional values (this fruit is cholesterol free and is rich in vitamin B1, B2, PP, A and C), and because this is an annual plant.

Material and Methods

Materials

Melons (*Cucumis melo* L., var. *reticulatus*, cultivars Harper and Proteo), of known cultivations, were selected on the basis of their size and maturity and on the visual characteristics, in particular for the attributes of homogeneity, freshness and integrity, while those with an irregular shape or eventually damaged were discarded. The chosen fruits were submitted to an accurate washing with an antibacterial detergent and rinsed, rubbing the peel, under tap water of good microbiological quality (EC=0.9-1.1 mS). Then, melons were washed with 1000 mg/l sodium hypochlorite solution at 14% (Clean Sud Industriale s.r.l.) by keeping them under the surface of the solution for one hour.

The operations of drying, cutting and sizing were carried out under a biosafety cabinet. Fruits were cut in slices with sterilized utensils and then packaged, singularly, in bags (PET 12+COEX/EVOH/PE95) with high barrier property to gas ($P_{O_2}<5$ $cm^3m^{-2}d^{-1}bar^{-1}$ at 23°C and 0% R.H.) and to water vapour ($P_{H_2O}<5$ $gm^{-2}d^{-1}$ at 38°C and 100% R.H.). The film was disinfected with ethyl alcohol (70% v/v) before being used for packaging (dimension 25x25 cm), in order to avoid further contaminations.

Melon samples were packaged in presence of four protective atmospheres (P.A.) and, then, stored for 4, 7 and 10 days at 5±1°C, as reported in Table 1.

Microbiological analyses

To determine microbiological quality of fresh cut melons during storage in modified atmosphere packaging, standard enumeration methods were used. Two samples of flesh melon (10 g) were aseptically taken from each P.A. condition at 0 (production day), 4, 7 and 10 days, then diluted in a Ringer solution (1/4 X) and homogenized with a Stomacher for 2 min. Samples were then serially diluted as needed for plating.

The following media and incubation conditions were used: plate count agar (PCA, Oxoid) for aerobic mesophilic (AMC), psychrotrophic (APC) and sporigens counts by pour plating, incubated at 7°C for 5 days and at 30°C for 72 hours, respectively; violet red bile glucose agar (VRBGA, Oxoid) for *Enterobacteriaceae* counts, incubated at 37°C for 24 h; dichloran rose-bengal chloramphenicol agar (DRBC, Oxoid) to enumerate yeast by spread plating and incubation at 25°C for 5 days. Microbial counts were performed in duplicate as described above and expressed as log_{10} C.F.U./g or cm^2, taking into account that, according the French regulation (Ministère de l'Economie des Finances et du Budget, 1988), $5x10^7$ CFU/g is the maximum acceptable contamination value at the end of the microbiological shelf life of these products.

The effect of washing in sodium hypochlorite (1000 mg/l) on surface microorganisms (C.F.U./g) in melons was also determined. Moreover, an HACCP plan was performed in order to individualize eventual critical points during the productive process.

Relative humidity

Relative humidity was measured by means of gravimetric analysis. Samples were inserted in a thermostated chamber for 24 h at 105°C, then were cooled off in desiccators and weighted again.

Colour evaluation

The parameters a*, b* and L* were determined by means of a colorimeter (MINOLTA Chroma Meter, mod. CR-300). The difference of colour (ΔE*), in comparison to the fresh product (t_0), was also determined, in according to the Hunter-Judd formula.

Firmness

Melon firmness, expressed in newton (N), was measured with a penetrometer (Gullimex

Fruit Pressure Tester, mod. FT 327), equipped with a 11.3 mm conical tip.

Chemical analyses

Measures of pH (Mettler Toledo, mod. MP 220) and °Brix (digital refractometer Abbe ATAGO, mod. DR-A1) were carried out on melon juice, obtained by centrifugation of samples.

Statistical analyses

Data were submitted to statistical analysis, in particular to Duncan Test ($P<0.05$), by means of SPSS 11.0 program, in order to individualize significant differences between samples of the two analyzed cultivars packaged in protective atmospheres.

Results and Discussion

To find the suitable gas composition that allows the storage of melon slices for a period of time greater than the shelf life of fresh melon slices placed in air, some preliminary tests were conducted, packaging the samples in presence of different mixtures of three gases (N_2, O_2, CO_2). It is known, from the literature (Myers, 1989; Oms-Oliu et al., 2008), that the melon tolerates concentrations of O_2 ranged between 2% and 8%, concentrations of CO_2 among 1% and 10%, and that levels of oxygen too low together with an elevated presence of carbonic dioxide, determine a transformation of the metabolism of the fruit, causing the proliferation of microorganisms further to alter the organoleptical characteristic of the product. The composition of the gas mixtures analyzed are reported in Table 1.

Table 1. Gas mixtures analyzed (%).

P.A.	N_2 (%)	O_2 (%)	CO_2 (%)
1 (control)	78	21	1
2	90	-	10
3	90	3	7
4	90	5	5

Tab. 2. Effect of washing in hypochlorite sodium (1000 mg/l) on surface microorganisms (C.F.U./g) in melons (mean ± st. dev.).

Microorganisms	Immersion in NaOCl			
	NO	10 min	30 min	60 min
AMC	$4.4*10^6±7.0*10^4$	$2.7*10^3±1.4*10^2$	$6.9*10^3±6.8*10^2$	$1.0*10^2±0.7*10$
APC	$6.7*10^5±3.5*10^4$	$1.8*10^5±2.8*10^2$	$4.3*10^5±3.5*10$	$1.0*10^2±1.0*10$
Sporigens	$7.0*10^3±8.0*10^2$	$2.5*10±7.0*10$	-	-
Enterobacteriaceae	$1.3*10^5±7.0*10^3$	$1.5*10^3±2.8*10^2$	-	$8.0*10±2.0*10$
Moulds	$4.4*10^6±7*10^4$	<10	<10	<10

AMC - Aerobic Mesophilic Count, APC - Aerobic Psychrotrophic Count

In a first step it was observed that slices of melon of both cultivars, if preserved for twenty-one days, showed an evident alteration of qualitative characteristics, in particular the proliferation of moulds, the appearance of unpleasant odors and alteration of colour that verged to the light orange. Consequently, the following experimentations were limited to 10 days.

Microbial investigations guaranteed the safety of the packaged melons during the whole storage period (Soliva-Fortuny et al., 2004). In fact, it was verified that the washing of melons before cut was one of the critical points of the process.

In Table 2 are reported the values of the microbial parameters observed on melons dipped for different times in sodium hypochlorite solution. It was possible to notice that the washing clearly reduces the initial values, in particular those of the coli spp. The same analyses also evidenced the idoneity to the use of melon slices after 4, 7 and 10 days of storage.

The weight loss of the slices during the storage time was more evident in the samples of melon belonging to the cv Proteo (Figure 1A), independently from the composition of the protective atmosphere. For the cv Harper the P.A. 1 seem to be the protective atmosphere that better limits the phenomenon of the weight loss (Figure 1B).

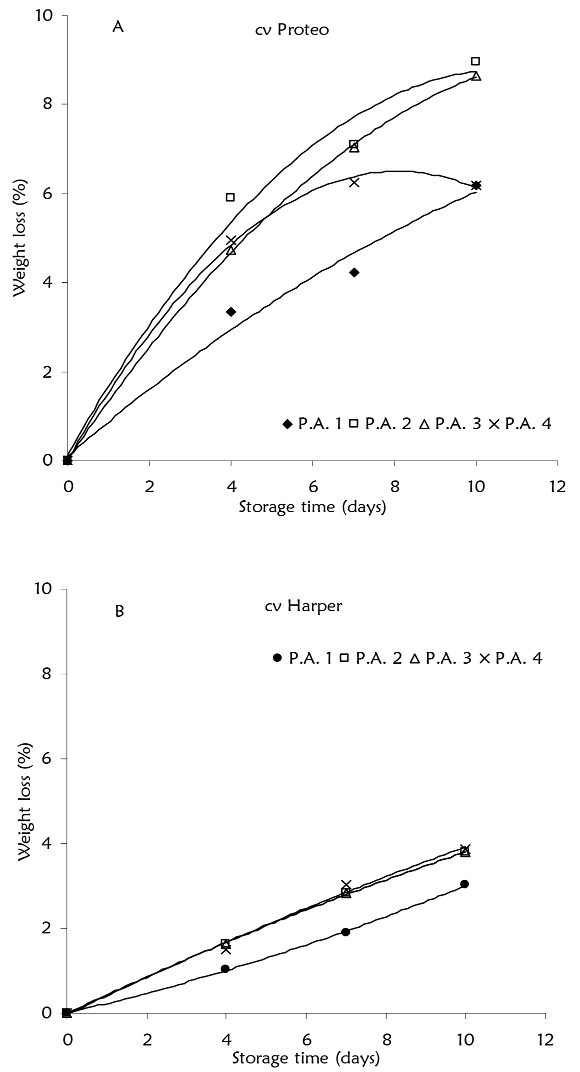

Figure 1. Weight loss in melons of cvs Proteo (A) and Harper (B) stored in protective atmospheres.

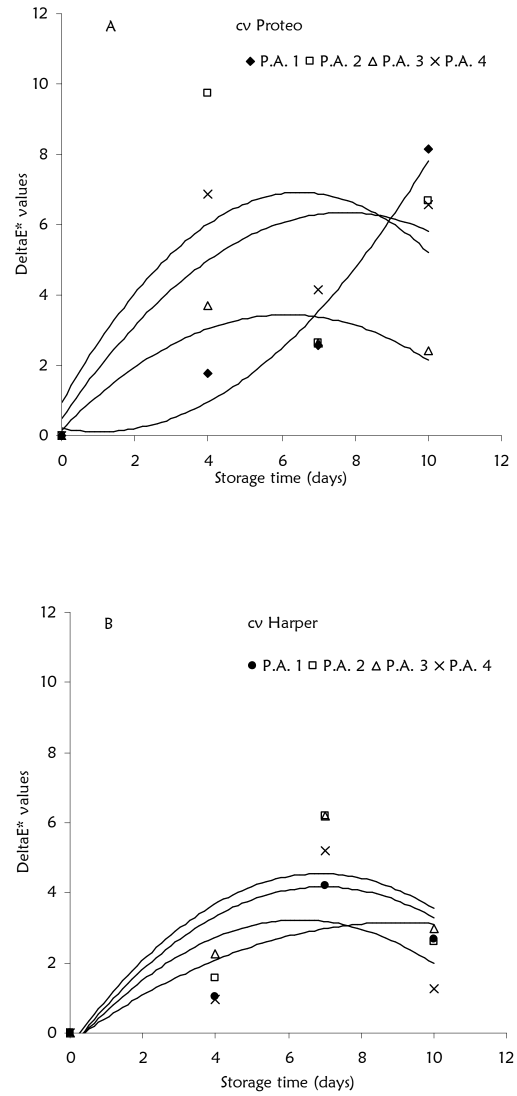

Figure 2. ΔE* time dependence in melons of cvs Proteo (A) and Harper (B) stored in protective atmospheres.

In the figures 2A and B are reported the values of ΔE* for both the cultivars with respect to slices of just cut melon. In both samples it can be observed that slices have the tendency to lose their original colour, that progressively becomes clearer. This alteration seems to interest less the cv Harper than the cv Proteo.

The figures 3A and B reported the variation during the storage time of melon firmness, respectively for the cv Proteo and the cv Harper, both of just cut slices and of slices packaged in presence of the different gas mixtures. For the cv Proteo (Figure 3A) a softening of the tissues is observed in those samples that were preserved in presence of gas mixtures containing concentrations of CO_2 of 7% (P.A. 3) and of 5% (P.A. 4). This behaviour can be attributed to the ethylene action, produced during the maturation of product. In particular when the product is close to elevated concentrations of carbon dioxide a big amount of this hormone is released.

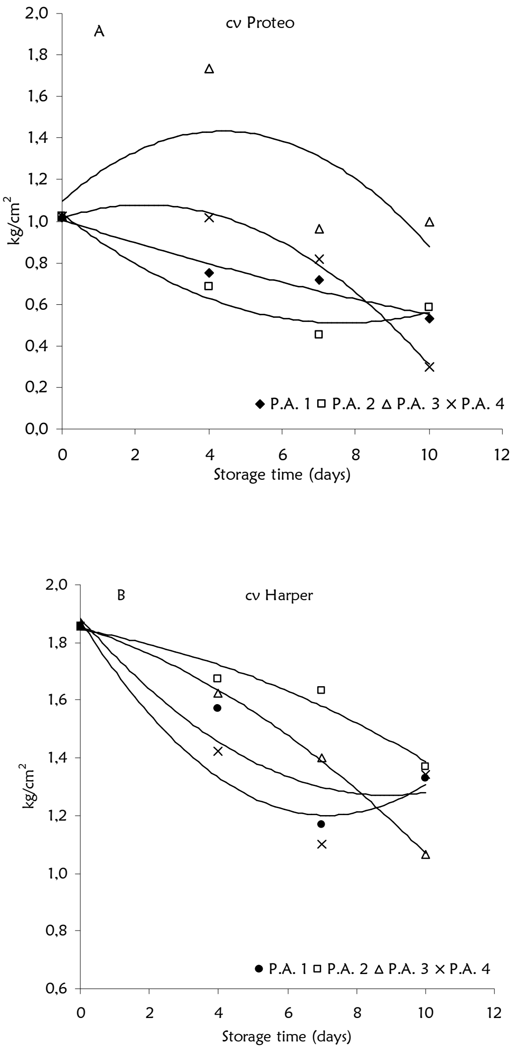

Figure 3. Firmness time dependence in melons of cvs Proteo (A) and Harper (B) stored in protective atmospheres.

For the melon samples belonging to the cv Harper (Figure 3B) a more limited variation of firmness of the slices was observed during the storage time. This result suggests that this cultivar is mostly lent to the production of slices in protective atmosphere.

One of the principal alterations of melons preserved in presence of protective atmosphere concerns the pH that, during the whole period of storage, decreased. At the end of the explored period, the pH reached lower values for the samples of the cv Proteo (Figure 4A), although is also to note the accented falls observed for the cv Harper (Figure 4B). It is worth to notice how the samples of the cv Proteo, preserved in the atmosphere containing the 7% of CO_2 (P.A. 3), after 10 days resulted sourer in comparison to those preserved in atmospheres with smaller concentration of CO_2. This result was in accord with the acidifying effect that CO_2 have when penetrates in vegetable tissues.

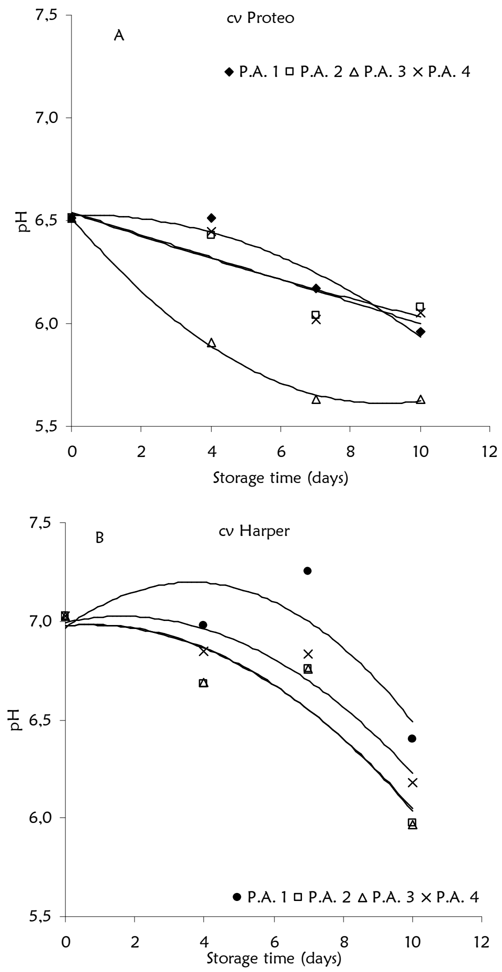

Figure 4. pH time dependence in melons of cvs Proteo (A) and Harper (B) stored in protective atmospheres.

In the figures 5A and B are reported, finally, the results of the refractometric analysis. For the cv Harper (Figure 5B) it was observed that the packaging in protective atmosphere caused a reduction of the sugar content of samples. The variation of °Brix follows a rather linear course and it can be connected to the action of the lactic microflora, responsible of the sugars's consumption further that the acidification of the substrate. Samples of melon belonging to the cv Proteo (Figure 5A), instead, did not showed significant differences among the four experimental conditions and during the storage period analyzed.

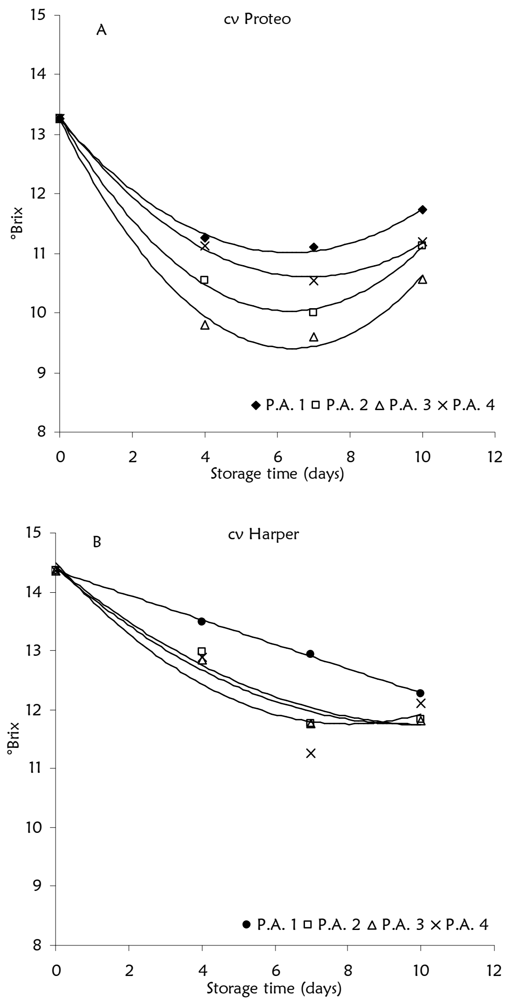

Figure 5. °Brix time dependence in melons of cvs Proteo (A) and Harper (B) stored in protective atmospheres.

Conclusions

Although the cv Proteo presented less variations in terms of the gravimetric and chemical-physical characteristics in comparison to the cv Harper, this last was lend better to the storage in protective atmosphere since more constant behaviour over the time corresponded to it.

Moreover, during the storage in the post-packaging period, melons belonging to the cv Proteo showed a phenomenon of structural chipping such to be not suitable to the packaging in protective atmosphere. The cultivar Harper, instead, showed always limited variations of the analyzed parameters but it was presumable that it is still necessary to work in order to resolve the manifested problematics so to improve the final qualitative level of product.

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