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Application of the matrixes engineering on the development of minimally processed Hass avocado (*Persea americana* Mill) with additions of vitamin C and calcium*

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Abstract

Introduction. Matrixes engineering is a method to obtain functional food that uses the vacuum impregnatiuon technique to add components to the structure of porous food. **Objective.** Determining the effect of adding vitamin C and calcium by means of vacuum impregnation (VI) on the quality parameters of minimally processed Hass avocado (*Persea americana* Mill) **Results.** The VI process provided better characteristics to the samples treated with it in comparison to those with a fresh treatment, with a reduction of the enzymatic browning (a higher luminosity >L* and less red coloring), conservation of the hardness, less microbiological countings and a higher sensorial acceptance **Conclusions.** Adding vitamins and calcium with the vacuum impregnation technique, VI, is an efficient method to conserve the quality characteristics of the minimally processed Hass avocado samples.

Key words: Minimally processed avocado, vacuum impregnation (VI), matrixes engineering, vitamin C, vitamin E, calcium.

Aplicación de la ingeniería de matrices en el desarrollo de aguacate Hass (*Persea americana* Mill) mínimamente procesado adicionado con vitamina C y calcio

Resumen

Introducción. La ingeniería de matrices es una metodología de obtención de alimentos funcionales que utiliza la técnica de impregnación al vacío para incorporar componentes en la estructura de los alimentos porosos. **Objetivo.** Determinar el efecto de la incorporación de vitamina C y calcio mediante la impregnación a vacío (VI) sobre los parámetros de calidad del aguacate Hass (*Persea americana* Mill) mínimamente procesado. **Resultados.** El proceso de VI resultó en mejores características para las muestras tratadas por VI que el tratamiento fresco, con una disminución del pardeamiento enzimático (mayor luminosidad >L* y menores coloraciones rojizas), conservación de la dureza, menores conteos microbiológicos y mayor grado de aceptación sensorial. **Conclusiones.** La incorporación de vitaminas y calcio, mediante la técnica de impregnación a vacío VI representan una metodología eficaz en la conservación de las características de calidad en las muestras de aguacate Hass, mínimamente procesado.

Palabras clave: aguacate mínimamente procesado, impregnación a vacío (VI), ingeniería de matrices, vitamina C, vitamina E, calcio.

Aplicação da engenharia de matrizes no desenvolvimento de abacate hass (*Persea americana* Mill) minimamente processado adicionado com vitamina C e cálcio

Resumo

Introdução. A engenharia de matrizes é uma metodologia de obtenção de alimentos funcionais que utiliza a técnica de impregnação ao esvaziamento para incorporar componentes na estrutura dos alimentos porosos. **Objetivo.** Determinar o efeito da incorporação de vitamina C e cálcio mediante a impreg-

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nação a esvaziamento (VI) sobre os parâmetros de qualidade do abacate Hass (*Persea americana* Mill*)* minimamente processado**. Resultados.** O processo de VI resultou em melhores características para as mostras tratadas por VI que o tratamento fresco, com uma diminuição do pareamento enzimático (maior luminosidade >L* e menores colorações avermelhadas), conservação da dureza, menores contagens microbiológicos e maior grau de aceitação sensorial. **Conclusões.** A incorporação de vitaminas e cálcio, mediante a técnica de impregnação a esvaziamento VI representam uma metodologia eficaz na conservação das características de qualidade nas mostras de abacate Hass, minimamente processado.

Palavras importantes: abacate minimamente processado, impregnação a esvaziamento (VI), engenharia de matrizes, vitamina C, VITAMINA E, cálcio.

Introduction

The avocado (*Persea americana* Mill) is a fruit belonging to the family *Lauraceae,* leathery skin, rough, pyriform, slightly green to black[1]. The avocado is mostly consumed as fresh fruit, and has a high biologic al value because of its low calorific value and high in protein, unsaturated fatty acids and monounsaturated, water soluble vitamins (C, B1, B2, B3, B8 and B9), lipo-soluble vitamins (A, D and E) and minerals (Fe, P and Mg), besides not contains cholesterol[2]. These nutritional characteristics, added with theirs low levels of sugars allow it to be recommended for use in people with diabetes and lipid disorders (triglycerides and cholesterol high)[3].

The primary problem in the industrialization of avocado fruit, is further deterioration occurred after the harvesting period, in which the fruits are continuing their normal physiological processes, and they are accelerated by minimal processing operations, that involving sorting, trimming, peeling and slicing or cutting, blending and packaging, which seek to achieve benefits of a freshness product, as sensory (aroma, flavor and texture) and nutritional characteristics, functional and convenience, ease of consumption, and less storage space occupation[3-5], besides effectively safeguard the product against the physical, mechanical, microbiological, biochemical (browning and oxidation) changes[6] and improvement the preservation and distribution, which is based almost only on refrigeration[7-9]. This transformation process increase the deterioration by biochemical oxidation, catalyzed by phenolase or polyphenoloxidase enzymes (PPO) present in the pulp, that are involved in oxygen-dependent reactions, transforming the o-diphenols to o-quinones, being able to covalently modify a wide range nucleophilic species within the cells, that leads to the formation of polymers brown, red or black of high molecular weight (melanins or melanoidins)[10,11], generating rejection of food in the consumer.

Several methods have been used in the inhibition of PPO biochemical activity on avocados, like the use of additives[6, 12-15]; exclusion of oxygen[14] pH adjustment[12,14,15]; the refrigeration[7-9], thermal treatment[17,18], and modified atmosphere packaging[5,16]. Likewise, there are other methodologies that are part of Food Engineering, such as matrix engineering that through vacuum impregnation (VI) technique incorporate compounds into the porous structure of foods[19-21], which allows simultaneous combine the above mentioned methods for improving product composition, as well as its characteristics or properties physical-chemical, microbiological and sensory[22, 23], without significantly altering the characteristics of fresh product. The matrix engineering has been used successfully in food matrices such as celery[24], fungi[25], cape gooseberry[26], mangoes[27], and others.

The aim of this study was to evaluated the effect of IV with an isotonic solution formulated with calcium and vitamin C, on the quality parameters of physicochemical, microbiological, bromatological and sensory qualitative avocado Hass (*Persea americana* Mill) minimally processed under two temperatures storage (4 and 12°C).

Materials and methods

Raw material and sample preparation

Avocado Hass (*P. americana* Mill) samples of Colombian origin, supplied by the company

TACO y NACHO Mex S.A. (Itagüí Antioquia) were used, selected on the basis of postharvest quality (mechanical or macrobiological damage). Avocados were sanitized in a solution Citrosan® (300ppm), peeling, pulping and cutting (minimal processing: MP) in cubic samples with less than 8cm^3 volume each one.

Vacuum impregnation treatment

Cutted avocado samples were subjected to the process of VI, according to the mathematical model proposed by Fito *et al*.[21] and Cortes *et al*.,[28] where the samples were immersed in an isotonic impregnation solution (IS) (NaCl 1.5% w/w, a_w equal to avocado), in a IV equipment, containing a metal chamber, electromechanical vibratory system to move and shake the samples in to IS, a vacuum pump DVR Dosivac 140, and vacuometer (0-760 mm Hg). The process consisted of immersing the avocado samples in to IS, and subjected to vacuum pressure of 150 mm Hg for 5 minutes and remained submerged at atmospheric pressure (640 mm Hg) for 5 min more. The VI process response was quantified in terms of X (fraction volumetric, m^3 IS/m^3 initial sample), X_{HDM} (real porosity, kg dissolution/kg sample) and ε_{IV} (effective porosity, m^{3}gas/m^{3}sample)[20]. The IS was determined from the preliminary values of X, from the mass balance in the impregnation system (avocado-IS)[28], (equation 1), where Y_i, X_i^{IV}, x^o_i are the mass fractions of component *i* in the SI, impregnated and fresh matrix respectively; ρ_{apm} and ρ_{dis} are apparent densities in fresh matrix and isotonic solution, respectably.

$$Y_i = \frac{X_i^{IV}\left(1 + X\,\frac{\rho_{dis}}{\rho_{apm}}\right) - x_i^0}{X\,\frac{\rho_{dis}}{\rho_{apm}}} \qquad (1)$$

Vitamin C (ascorbic acid, 99% pure) in to IS was added according to Resolution 333 of 2011 (Min Social Protection, Colombia), in order to obtain a percentage of recommended daily value (RDV) of 30% per 100g fresh avocado and calcium of 10%, incorporated in relation of 40mg citrate Ca^{+2} /g low methoxyl pectin, to induce a IS soft gel in the intercellular spaces. Citric acid as conserver was added at 120 mg/100 g fresh avocado.

Storage

Fresh and IV avocado samples were packaged in thermoformed trays of polyethylene terephthalate/low density polyethylene(PET/LDPE, permeability negligible), coated with laminated low density polyethylene (LDPE) of 54µ thick, on presentations of 200g/tray, stored at a temperature of 4 and 12°C, monitoring at 0, 3, 6, 9, 12 and 15 days.

Physico-chemical characteristic

Moisture (%) and solid content (ºBrix) of were gravimetrically measured, following A.O.A.C 930.15/90[29] and NTC4624[43] respectably; pH followed NTC 4592[44] using a potentiometer (Hanna pH 211), water activity (a_w), using a dew point hygrometer (Decagon Aqualab series 3TE at 25°C), titratable acidity expressed as percentage of citric acid followed NTC 4623[1]. Colour values on meso and exocarp surface of the samples were acquired with a spectrocolorimeter (X-RITE with illuminant D65, model SP62) by measuring the reflection spectrum, CIE-L*a*b* uniform colour space, where L* indicates lightness, a* indicates chromaticity on a green (–) to red (+) axis, and b* chromaticity on a blue (–) to yellow (+) axis. Colour coordinates were obtained from a 10º angle observer and an aperture of 64 mm optical glass built; besides chrome (C*) were calculated.

Changes in mechanical properties were studied from puncture tests on fresh and IV avocado samples using a texture analyzer (TA/XT2i Stable Micro Systems), using a metal plunger 2 mm in diameter and a deformation rate of 4 mm/s and a depth 20mm. The parameters analyzed were: firmness of the force curve (F) - distance from deformation (D)[30].

Analysis of composition

Calcium mineral was determined by atomic absorption spectrophotometry with flame NTC-5151[1], and vitamin C by the volumetric method of iodine 2,6 dichlorophenol indophenol[31].

Microbiological parameters

Microbiological values were obtained by counting forming colony units of aerobic mesophilic bacteria, molds and yeasts, Staphylococcus aureus, total coliforms, fecal coliforms, Salmonella sp and lactic acid bacteria, performed according to the manual for microbiological assays[32] recommended for salads, raw fruits and vegetables.

Sensory analysis

A panel of 5 trained judges carried out a sensory analysis of fresh and IV samples of avocado during storage, using a test of quantitative response scale followed the NTC5328/2004[45]. The attributes evaluated were: color, taste, and odor/flavor characteristics, objectionable odor, bitter taste, objectionable taste, firmness and overall quality. Rated intensity scale of 7 points was used, where 0 = absent, 1 and 2 (mild), 3 (lower middle), 4 (medium), 5 (upper middle), 6 and 7 = intense.

Experimental design and statistical analysis

The results were analyzed based on ANOVA, using the statistical package Statgrafics Centurion XV (Statsoft, USA), using a multivariate model completely randomized of fixed effects factors, by LSD (least significant difference) applied to evaluate differences among treatment means, with a level of meaning of 95% ($P < 0.05$).

Results

Vacuum impregnation

Impregnation parameters X, X_{HDM} and ε_{IV} obtained initial impregnation with isotonic solution were 0.111±0.009 $m^3_{dis}/m^3_{fresh\text{-}avocado}$, 0.123±0.010 $kg_{dis}/kg_{impregnated\text{-}avocado}$ and 0.207±0.014 $m^3_{air}/m^3_{fresh\text{-}avocado}$, respectively. Due to the interactions of pectic component of cell walls with Ca ions[27], the global parameters of impregnation obtained with the IS (added), were found to be slightly low than the averages of the preliminary values used for design solutions (X: 0.101±0.007 $m^3_{dis}/\ m^3_{fresh\ avocado}$, X_{HDM}: 0.112±0.005$kg_{dis}/kg_{\ impregnated\text{-}avocado}$ and 0.1803±0.022 $m^3_{air}/m^3_{fresh\text{-}avocado}$). This behavior influenced the final levels of vitamin C in VI samples of avocado were different from the objectives of addition, as other researches have obtained[19, 21, 28].

Physico-chemical characteristic

Physicochemical parameters evolution, a_w, moisture, pH, acidity, °Brix, for samples of MP avocado, stored at 4 and 12°C for storage times are shown in table 1. ANOVA showed significant statistical differences ($P <0.05$) for VI treatment effect, time and temperature of storage for all physicochemical parameters. Physicochemical values in fresh product are similar to those reported by Ortega-Mendoza *et al.*[30], for avocados Hass at time 0. Slight changes during the storage for the a_w and ºBrix are promoted by the establishment of thermodynamic equilibrium between the atmosphere packaging and the samples[25].

Moisture had a slight increase at the end of storage time, with higher values for fresh samples. This situation is attributed to that during the establishment of thermodynamic equilibrium between the atmosphere packaging and the product, part of the fraction of water loss after the interchange; return to product by condensation and rehydration[16, 25]. IS used and acidulants incorporated, generated a %acidity increase and pH decreased, respect to fresh product, although not present for all times, precisely because of the complexity and heterogeneity of the food matrix. Similar results have been reported in other food matrices under VI process with fortificated emulsions[34, 26].

Physicochemical variable most affected by IV process was firmness (fig. 1), it presented severe changes attributed to entry of Ca content of the SI, to inside of cellular matrix and the interaction with hydrodynamic mechanism, that affect the microstructure and mechanical properties of solid[19, 27], giving a better resistance to breakage, acting as firmness improvement of product[34]. Although, samples treated with IV present a highest resistance to deformation, this characteristic decreased during storage time, resulting in samples with low firmness levels at the end the control. Situation mainly due to structural deformations of the samples as a result of pressure changes of the system, which cause tissue cell separation, affecting the mechanical behavior[21, 22] and rate of relaxation increase versus applied stress[35] by gas exchange during the process IV. Similar results has been reported in research with others food matrices[36, 37].

Table 1. Mean values with LSD intervals (95%) of the physicochemical parameters

	Fresh Avocado	Storage(Days)				
4°C	**0**	**3**	**6**	**9**	**12**	**15**
Xbh	76,9±(0.5)	78.3±(0.5)	79.1±(0.5)	77.5±(0.6)	79.66±(0.8)	80,23±(0.7)
aw	0.987± (0.002)	0.986± (0.001)	0.988± (0.001)	0.987± (0.001)	0.987± (0.001)	0.987± (0.001)
pH	7,12±(0.03)	6.80±(0.01)	6,74±(0.02)	7.25±(0.02)	6.77±(0.03)	6.18±(0.05)
Acidez	0.044±(0.01)	0.051±(0.01)	0.041±(0.01)	0.033±(0.01)	0.038±(0.01)	0.037±(0.01)
°Brix	5.1±(0.1)	6.0±(0.1)	5.5±(0.2)	6,0±(0.1)	5.5±(0.1)	4.5±(0.1)
12°C	**0**	**3**	**6**	**9**	**12**	**15**
Xbh	76,3±(0.5)	78.8±(0.5)	77.57±(0.5)	79.78±(0.6)	82,32±(0.8)	81,53±(0.7)
aw	0.987± (0.002)	0.987± (0.001)	0.987± (0.001)	0.987± (0.001)	0.988± (0.001)	0.989± (0.001)
pH	6,7±(0.03)	7.08±(0.01)	6,3±(0.02)	6,8±(0.02)	6.9±(0.03)	6.8±(0.05)
Acidez	0.037±(0.01)	0.046±(0.01)	0.038±(0.01)	0.030±(0.01)	0.036± (0.01)	0.036±(0.01)
°Brix	5.6±(0.1)	5,8±(0.1)	5.3±(0.2)	5.7±(0.1)	5.0±(0.1)	5.0±(0.1)
IV 4°C	**0**	**3**	**6**	**9**	**12**	**15**
Xbh	80,05±(0.5)	75.15±(0.5)	74.52±(0.5)	74.09±(0.6)	74.42±(0.5)	75,216±(0.7)
aw	0.985± (0.002)	0.983± (0.001)	0.983± (0.001)	0.983± (0.001)	0.984± (0.001)	0.984± (0.001)
pH	4,15±(0.03)	3.9±(0.01)	3,75±(0.02)	3,64±(0.02)	3.58±(0.03)	3,63±(0.05)
Acidez	0.212±(0.01)	0.204±(0.01)	0.209±(0.01)	0.219±(0.01)	0.207±(0.01)	0.235±(0.01)
°Brix	5.3±(0.1)	5,2±(0.1)	5.3±(0.2)	5.5±(0.1)	5.22±(0.1)	4.95±(0.1)
IV 12°C	**0**	**3**	**6**	**9**	**12**	**15**
Xbh	80,85±(0.5)	75.6±(0.5)	76.73±(0.5)	74.5±(0.6)	76.90±(0.8)	77,605±(0.7)
aw	0.985± (0.002)	0.984± (0.001)	0.984± (0.001)	0.981± (0.001)	0.984± (0.001)	0.985± (0.001)
pH	4,25±(0.03)	4.66±(0.01)	4,53±(0.02)	5,13±(0.02)	4,98±(0.03)	5.95±(0.05)
Acidez	0.206±(0.01)	0.201±(0.01)	0.221±(0.01)	0.245±(0.01)	0.229± (0.01)	0.240±(0.01)
°Brix	5.1±(0.1)	5.5±(0.1)	4.9±(0.2)	5.3±(0.1)	3,53±(0.1)	4.17±(0.1)

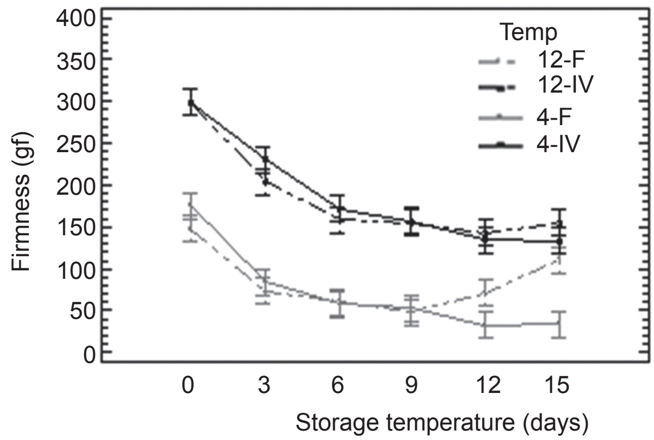

Figure 1. Firmness instrumental on avocado samples

All treatments, presented a decrease in firmness through the storage time. This phenomenon is mainly attributed to the breakdown and shortening of the cellular tissue, obtained by cutting of the avocado, causing an alteration of the turgescency degree, native liquid and solutes loss present in the product[25, 36] which ones contributing structure, that provoked the loss of mechanical strength and increased interaction area exposed to enzymatic action and deterioration[6, 11] and water loss of the structure[38]. Similar phenomena have been reported for minimally processed derived from foods of high biological activity, which showed a negative output response after the slicing or cutting process, due to damage, with cell separation followed by fracture and deformation of the product during storage in pears[39], apple, strawberry, peach and watermelon[33].

Firmness in fresh product was also affected by storage temperature at 12°C. However, the temperature was not a crucial factor contributing to changes in the product; due both storage temperatures allow the maintenance of respiratory rate[5]. Figure 2 shows the evolution of the colour parameters L*, a*, b*, and C* in avocado samples on exocarp surface.

Colour parameters presented significantly changes (P<0.05) for effect to IV treatment, time and temperature of storage (fig. 2). Colour evolution in the fresh and VI product, showed a gradual degradation kinetics and similar distribution in mesocarp and excarp surface, evidenced by a decrease in Lightness values (L*), more low for mesocarp (values of mesocarp are not showed, exocarp is explained due this part of fruit is really important for the acceptance of consumer) than for the exocarp for both treatments, fresh and VI process. Saucedo-Pompa *et al.*[40], reported significant changes in all colour parameters of fresh and treated avocado with edible coatings. These changes were manifested by decreased values of L* and b* and an increase in the values of a*. L* value is an excellent index for evaluating the color of avocado fruits as an indicator of browning.

Browning of avocado fruit can be caused by enzymatic browning catalyzed by PPO enzymes or destruction of material by degradation of chlorophyll as chlorophyll oxidase enzymes, chlorophyllase or lipolytic hydrolases present in the cells and released by the trauma suffered in fruit tissue[7, 9, 14, 15]. The changes and the kinetics of degradation of L* and a* are explained by this phenomenon, where the darkening is indicative of the formation of dark compounds, while a* reflects the loss of green color, derived from the degradation of chlorophyll content[14]. The addition of SI to samples of avocado, showed an improvement in the maintenance of initials characteristics of the colour on the parameter L*, compared with the fresh product.

Soliva-Fortuny *et al.*[14] demonstrated a positive effect by the addition of different antioxidants on the inhibition of browning, whose effect is enhanced when these are combined with other technological processes[6, 14, 15, 24, 25]. Moreover, decrease in the L* value was presented by effect of temperature at 12°C, associated with enzyme activity increased. These values are consistent with those reported by other authors, showing a decrease in the values of L* on the surface of the fruit; according to the increase in the temperature employed[14].

Chromaticity a* and b* showed significantly changes attributable to storage time, finishing with color samples predominantly reddish-green to both surfaces of the fruit, but more intense for mesocarp. In general, at the end of storage, even under the IV treatment, all avocado samples were less lightness and reddish-green increased. This situation could be associated to the peeling of the fruit that enhances the browning phenomenon[2, 6, 7, 15, 30]. Other authors, have been reported similar changes in avocado colour in relation to maintenance of green on the skin and mesocarp discoloration, even under different treatments[6, 7, 14].

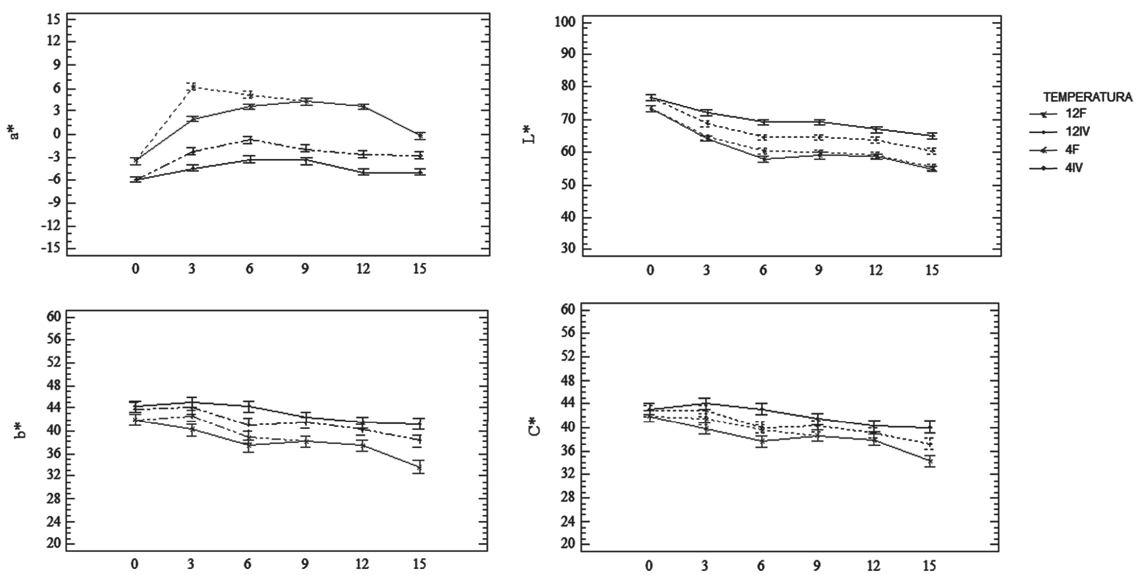

Figure 2. Parameters of colour on the exocarp surface of avocado

Analysis of composition

The table 2 presents the levels of calcium and vitamin C, for the treatments evaluated. Fortification levels for Ca were lower than those fixed under the criteria described, due to the lower income of the SI inside the cellular matrix by distribution of particle size. The increased at the end of storage time was attributed at establishment of thermodynamic equilibrium and dehydration derived[25]. Vitamin C values reached similar fortification levels (29.7%) of the criteria have been established, which makes this fruit an excellent matrix for incorporating this component in order to be used in the control of oxidation over storage time. Slow degradation kinetics of this component ($Y=0.119t+19.71$, $R^2=0.95$) denotes a small spending over time, mainly due to the presence of other antioxidant vitamins type in the structure of fresh product and design of the SI, which provided good availability antioxidant in the colloidal system and the cell, compared with fresh product.

Microbiological parameters

Avocado samples treated with IV, had lower microbial counts for all microorganisms tested ($P<0.05$), much less at the end of storage time, a phenomenon attributable to the composition of the SI (conservers and acidifiers), which in turn kept slight changes in the physicochemical variables associated with increased microorganisms (pH, a_w and moisture). Even for fresh product, the values found during storage times remain below the limits set by current regulations. Mesophilic and bacteria behavior observed in the first nine (9) days, were constant in storage at 4 and 12°C (figure 3). This results has been reported in others studies[41], associated with this type of microorganism can survive temperature ranges below 7°C, although the lag phase and generation time increases with decreasing storage temperature[42], can proliferate during any abrupt change in food storage conditions. Molds and yeasts showed similar behavior during storage under both temperatures, lower growth for mold. For BAL, even under high variability, their growth was not influenced by storage temperature. although their growth not represented major changes affecting the structure of the matrix of the avocado, the increase in enzyme activity that could generate the presence of LAB that influence the sensory characteristics[42].

The application of disinfection practices with organic acids, allowed not growth of pathogens, for all treatments.

Table 2. Levels of calcium and vitamin C, for the treatments evaluated

	Treatment	mg /100g	%VDR
Calcium	0-F	11.0±(0.01)	0.011±(0.01)
	15-F	19 .0±(0.02)	0.028±(0.01)
	IV-0	54.6±(0.20)	5.45±(0.02)
	15-IV	58.3±(0.03)	5.83±(0.20)
Vitamin C	0-F	7.0±(0.2)	11.7±(0.1)
	IV-0	19.6±(0.2)	32.7±(0.2)
	IV-3	19.3±(0.3)	32.1±(0.2)
	IV-6	19.1±(0.2)	32.1±(0.3)
	IV-9	18.9±(0.1)	31.5±(0.2)
	IV-12	18.2±(0.2)	30.3±(0.2)
	IV-15	17.8±(0.2)	29.7±(0.3)

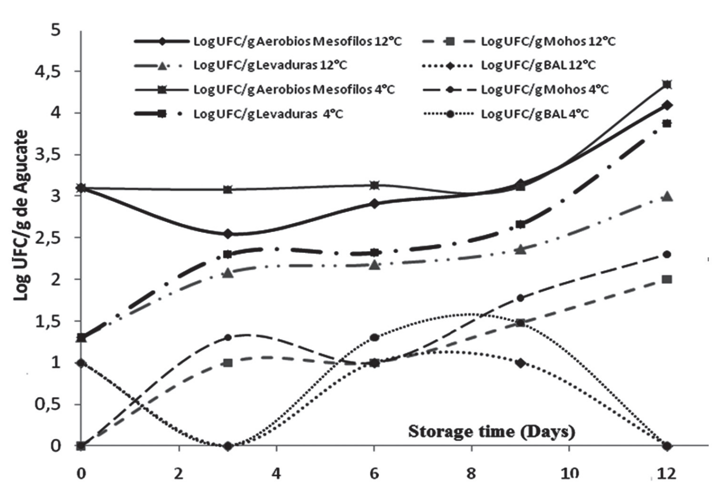

Figure 3. Microbiological analysis of samples of fresh avocados

Sensory analysis

The descriptors evaluated showed a substantial change with values tended to quickly decline to deteriorate and low-medium intensity in the case of the product without SI adding on day 3 of storage, situation confirmed by instrumental color evaluation, in addition to low scores for taste, flavor, odor, color and firmness characteristics, and increased of deteriorate variables (objectionable), which generated fresh samples rejection. This situation is mainly attributed to the interaction of the accelerated kinetics of degradation and thermodynamic equilibrium, by effect of cell damage caused during the cutting process, thus unchaining an activity of PPO increased on this product. While the samples treated by IV process with SI showed excellent sensory characteristics until 6 days of storage, fact attributed to addition of conservatives, antioxidants, and calcium as texture improver (figure 4).

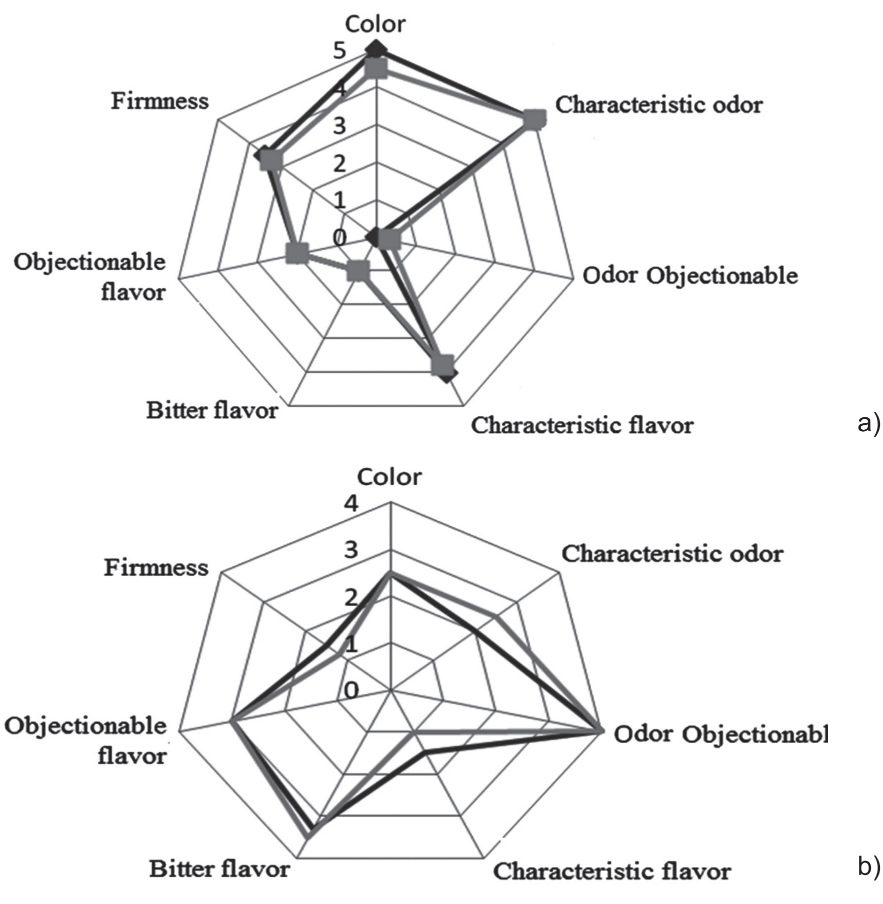

Figure 4. Sensory parameters evaluated on day three of storage a) IV tratment, b) Fresch. Black line 4°C. Gray line 12ºC

Conclusions

Engineering matrices through the VI technique is presented as an effective methodology for incorporating minerals and antioxidants in the structure of the avocado, enabling improved quality characteristics compared to the fresh product. The minimal processing is the main cause of the deterioration of the shelf life of the product that which is necessary to continue the search for scientific and industrial solutions, including using the VI process with other methodologies in the conservation of avocado minimal processed.

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