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EVALUATION OF THE PHYSICOCHEMICAL, PHYSICAL AND SENSORY PROPERTIES OF FRESH CAPE GOOSEBERRY AND VACUUM IMPREGNATED WITH PHYSIOLOGICALLY ACTIVE COMPONENTS

EVALUACIÓN DE LAS PROPIEDADES FISICOQUÍMICAS, FÍSICAS Y SENSORIALES DE UCHUVAS FRESCAS E IMPREGNADAS AL VACÍO CON COMPONENTES FISIOLÓGICAMENTE ACTIVOS

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ABSTRACT

Background: Functional Foods are considered nowadays by consumers as the range of foods of major interest. **Objectives:** The aim of the present work was the evaluation of color, texture and sensorial properties of fresh Cape Gooseberry (FG) and vacuum impregnated Cape Gooseberry (IG) with calcium and vitamins B_9, C, D and E during storage at 4ºC. **Methods:** Entire cape gooseberries were vacuum impregnated (VI) with tocopherol and cholecalciferol emulsified in aqueous phase with sucrose, ascorbic acid, folic acid, calcium chloride, calcium fumarate, low methoxyl pectin, isolated soy protein, tensoactives and preservatives. The texture was determined from puncture assays, and the color from the CIE Lab coordinates. The sensorial profile was determined with the aid of trained panelists, through a multidimensional approach of characteristic descriptors of general appearance, odor, taste and texture. **Results:** The instrumental values of color and texture for IG were significantly different from the FG, because are being softer, more elastic, darker, brighter and of less color saturation. The samples of FG and IG presented intense sensorial characteristics in the descriptors orange color, brightness, spherical uniformity, smooth surface, fresh appearance, odor, cape gooseberry characteristic taste and frutal, fleshy texture, juicy, firmness and turgidity. By the effect of VI process the most relevant significant differences were the descriptors orange color, superficial stains, fresh appearance, sweet taste and cape gooseberry characteristic taste, soft texture, firmness and juicy; whereas for the effect of storage time were fresh appearance, dehydrated appearance, peduncle cicatrization, aromatic odor, overripe, cape gooseberry characteristic taste, frutal taste, soft texture, juicy, firmness and turgidity. **Conclusions:** The VI significantly affects the objective assessment of color and texture, finding correspondence with the sensorial evaluation; nonetheless, the general quality of the FG presented a greater score than those presented by IG.

Keywords: *Physalis peruviana* L., vacuum impregnation, color, texture, sensory evaluation.

RESUMEN

Antecedentes: Los alimentos funcionales son considerados actualmente la gama de alimentos de mayor interés por los consumidores. **Objetivos:** El objetivo fue evaluar el color, la textura y las propiedades sensoriales de uchuva fresca (UF) e impregnada al vacío (UI) con calcio y vitaminas B_9, C, D y E, durante

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el almacenamiento a 4°C. **Métodos:** Las uchuvas enteras fueron impregnadas al vacío (IV) con tocoferol y colecalciferol emulsificados en fase acuosa de sucrosa, ácido ascorbico, ácido fólico, cloruro de calcio, fumarato de calcio, pectina de bajo metoxilo, proteína de soya aislada, tensoactivos y conservantes. La textura se determinó a partir de ensayos de punción y el color de acuerdo a las coordenadas del CIE-Lab. El perfil sensorial se realizó con panelistas entrenados a través de una aproximación multidimensional de descriptores propios del aspecto general, olor, sabor y textura. **Resultados:** Las valoraciones instrumentales de color y textura en las UI fueron significativamente diferentes que las UF, por ser más blandas, elásticas, oscuras, y brillantes y de menor saturación de color. Las muestras UF y UI presentaron intensas características sensoriales en los descriptores color anaranjado, brillo, uniformidad esférica, superficie lisa, aspecto fresco, olor y sabor característico a uchuva y frutal, textura carnosa, jugosa, firme y turgencia. Por efecto del proceso IV las diferencias significativas más relevantes fueron: los descriptores color anaranjado, manchas superficiales, aspecto fresco, sabor dulce y característico a uchuva, textura blanda, firmeza y jugosidad; mientras que por efecto del tiempo de almacenamiento fueron: aspecto fresco, apariencia deshidratada, la cicatrización del pedúnculo, olor aromático, sobremaduración, sabor característico a uchuva, sabor frutal, textura blanda, jugosidad, firmeza y turgencia. **Conclusiones**: La IV afecta significativamente las valoraciones objetivas de color y textura, encontrándose correspondencia con la valoración sensorial; sin embargo, la calidad general de la UF presentó un mayor score que las UI.

Palabras clave: *Physalis peruviana* L., impregnación al vacío, color, textura, evaluación sensorial.

INTRODUCTION

Cape gooseberry (*Physalis peruviana* L.) is a pulpy round berry of the Solanaceae family, a typical fruit from the Andes region in South American. The pulp (pericarp) is completely edible and smooth, it contains numerous small lens-shaped seeds and its peel (exocarp) is thin, elastic, smooth and shiny (1, 2). The fruit is entirely covered by a calyx that protects it from the environment, segregating a sticky substance produced by glandular tissues located at the base, whose function is to repel insect attack (3). Cape gooseberry colombian ecotype is characterized by a bright orange color, some intense pleasant aromas, and a balanced sweet-acid taste (14-15° Brix, acidity from 1.6 to 2.0% and pH from 3.6 to 4.1) (4). This fruit has high vitamins A and C levels (5, 6), as well as minerals such as calcium, iron and phosphorus (7). Those features have let identifying gooseberry as a promising fruit for exportation by the Colombian Ministry of Agriculture and Rural Development (8, 9). Additionally, cape gooseberry has been recognized for its medicinal properties such as anti-asthmatic, diuretic, antiseptic, sedative, analgesic, antiparasitic, antidiabetic among others (10).

In human feeding, new trends are associated with fruits and vegetables consumption due to their well-known nutritional properties, and in the healthy food purchases (11, 12). This behavior has encouraged the Minimally Processed Foods Industry to develop products with functional characteristics (13). Functional foods look as conventional products, they are consumed as a portion of a normal diet, and besides their nutritive basic function, they operate in multiple organ systems like gastrointestinal, cardiovascular and immune, but also in nutrient metabolism, gene expression, oxidative stress and the psychic sphere (14).

Vitamins are organic compounds that humans need for their appropriate cells functioning. Some of them are not synthesized in human organism, for example, vitamins C and E, which makes necessary to ingest them from foods. Vitamins C and E have excelled by their antioxidant power because they counteract free radicals, which are known for its participation in the initiation phases of some degenerative diseases (15). Likewise, vitamin B_9 or folic acid, is required in DNA and RNA synthesis, and in some aminoacids metabolism, preventing defects in the fetus neural tube, like Spina Bifida (16); for this reasons, they are indispensable in expectant mother's diet. The most important function of vitamin D, is to stimulate the absorption, fixation and elimination of calcium, thanks to the specific receptors that human beings have in their intestines, bones and kidneys (17, 18), which is necessary for the development and normal growing of skeleton and teeth, with a sufficient calcium intake. This mineral consumption is very important in childhood and adolescence for developing a good peak bone mass, especially in females. A minimally processed product with those benefits generates national and international expectation, especially in women who have a higher concern about diet – health relation (19).

One effective process for the development of Functional Foods is the vacuum impregnation (VI), which is a process of mass transfer of physiologically active compounds (PAC), contained in an impregnation liquid, to the porous tissues, thus promoting compositional changes in short time and low temperatures (20). Gooseberry has been fortified through the VI technique, obtaining minimally processed products with high levels of physiologically active compounds (PAC) and are stable during storage (21 - 23). Some other researchers have demonstrated the IV effectiveness in incorporating PAC into porous fruits or vegetables matrices (e.g. Vitamin E in apple, strawberry, cape gooseberry, celery and cucumber; calcium, zinc and vitamins C and E in edible mushrooms and antioxidants in banana) (24 - 29).

Some biochemical changes along with water loss, enzymatic polysaccharides hydrolysis (starch, pectin and cellulose), and respiration increasing rate are produced during vegetables maturation and senescence. This factors cause the tissues softness (30). The color change in fruits is due to the reduction of enzymes responsible of chlorophyll synthesis (compounds that give them green color), while those that synthesize carotenoids and xanthophylls are activated; these substances give yellow and red colors respectively. The double bonds breaking (oxidation) of these pigments causes a decrease in brightness, and after the gray colors development (31). All these normal senescence processes, along with the microbial growing, affect notoriously the sensory properties of fruits, which demerits its general quality (32).

Functional foods, besides providing health benefits that prevent illnesses, should be desirable from the sensory point of view, presenting nice colors, textures, shapes and flavors. One of the most important methods in sensory evaluation is the descriptive tests; this allows finding the most relevant features that provide maximum information of a specific product. This assessment is based on the detection and description of qualitative and quantitative sensory aspects by trained taster groups, who provide quantitative values that are proportional to the perceived intensity of every attribute. They are able to perceive changes caused by a treatment or by the time (33).

The aim of the present investigation is to evaluate color, texture and sensory properties in fresh gooseberry (no treated) and vacuum impregnated gooseberry with calcium and vitamins B_9, C, D and E, during storage at 4°C.

MATERIALS AND METHODS

Vegetable raw material

It was used fresh cape gooseberries (FG) (*Physalis peruviana* L.) colombian ecotype (La Unión, Antioquia), with weights between 6 and 8 g without calyx, in a maturity level between 4 and 6 according to the Colombian Technical Standard, NTC 4580 (34). FG was disinfected by immersion in a chlorine solution of 50 ppm.

Vacuum Impregnation

The ingredients of the impregnation emulsion (IE) were ascorbic acid (vitamin C), cholecalciferol (vitamin D_3), DL-α-tocopherol acetate (vitamin E), folic acid (vitamin B_9), calcium chloride, calcium fumarate (Σ 8.35% p/p), sucrose, Tween 80, Span 60, potassium sorbate, low methoxyl pectin, isolated soy protein and potable water (Σ 91.65%). The IE was homogenized in an Ultraturrax machine (UTL 50 INLINE, Janke & Kunkel IKA®- Labortechnik) at 10.000 rpm during 10 minutes. The quantity of each PAC is the result of a mass balance between fruit and IE (20), so it was previously obtained the impregnation mass fraction ($X = 0.0347 \pm 0.0067$) (1) according to methodology described by Fito *et al.*, 1996 (35), and Salvatori *et al.*, 1998 (36). Fortification criteria selected was: 20% of the daily reference values (DRV) for calcium and vitamins D and B_9, and the 50% for vitamin E, in a portion size of 200 g, according to Ministry of Social Protection, 2011 (37). VI process was performed in a vacuum stainless steel chamber, according to methodology described by Fito *et al.*, 1996 (35), and Salvatori *et al.*, 1998 (36), with a vacuum pressure of 31.4 mm Hg during 5 minutes, followed by 5 minutes at local barometric pressure (640 mm Hg).

Storage

The FG and the impregnated cape gooseberries (IG) where packed in perforated thermoformed boxes of polyethylene terephthalate, with ≅200 g capacity, and they were stored at 4°C during 21 days in light absence.

Physicochemical Properties

It was measured: Soluble solids (°Brix) in a manual refractometer (Leica Auto ABBE) at 20°C (AOAC 932.12/2002); titratable acidity, expressed as citric acid percentage (AOAC 942.15/2002); and moisture, by drying at 105°C during 6 hours (A.OAC 925.45/2002) (38).

Instrumental texture

For texture determination was used the texture analyzer (TA:XT2 Stable Micro Systems), by puncture tests with 50 kg load cell, 2 mm/s speed and 10 mm penetration distance. The tests were performed in the equatorial zone of all gooseberries with a metallic plunger 2 mm in diameter. During puncture, force in Newton (N) was plotted vs. the distance in millimeters (mm) traveled by the plunger, and it was calculated: the epidermis force (F_{max}), that represents the maximum mechanic resistance or force data; pulp force (F_{pulp}), from the average of the semi constant data force recorded after F_{max}; and the elasticity module (ε), calculated as the slope of data before reaching F_{max}, where higher values correspond to lower elasticity.

Instrumental color

It was determined the color coordinates CIE-$L^*a^*b^*$, hue (h_{ab}^*) and chroma (C_{ab}^*), from the reflection spectrum of FG and IG, taken on the equatorial zone and peduncle area, using the spectrocolorimeter X-RITE, SP64 model, with the illuminant D_{65} and the 10° observer as reference.

Sensory Evaluation

A sensory profile was performed by multidimensional approximation method according to the Colombian Technical Standards NTC 3501 (39), NTC 3925 (40) and NTC 3932 (41), in fresh and impregnated gooseberries with 3, 18 and 21 storage days, with 10 training judges, in individual panels with artificial light at 25°C and 72% relative humidity. The descriptors of general appearance, odor, flavor and texture in FG and IG were identified and selected, allowing getting the maximum information about its sensory attributes. Selected descriptors were assessed on a hedonic scale from 0 to 5, where zero represents no perception, 1 is weak, 2 is less weak, 3 is average, 4 is less strong and 5 is strong; furthermore, general quality was assessed on a scale of 0 to 3, where 0 is no quality.

Data analysis

Completely randomized Factorial design (T x Z x D x L x R: treatments x zones x days x lots x repetitions) was performed for: physicochemical properties (2x1x1x2x5); texture (2x1x8x3x5); color (2x2x8x3x5); microbiological evaluation (2x1x8x3x2); and sensory evaluation (2x1x3x1x10). Data was analyzed using an analysis of variance ANOVA, applying the LSD method (Low significant differences) as multiple comparisons method, with 95% significance ($\alpha = 0.05$) and 80% of power, using the statistic software Statgraphics Centurion XV.

RESULTS

Physicochemical properties

ANOVA did not report significant differences ($p < 0.05$) for VI effect in physicochemical analysis. These are the results: 14.74 ± 0.6 and 15.10 ± 0.5 °Brix; 1.65 ± 0.31% and 1.67 ± 0.34% acidity; 79.87 ± 0.73% and 79.98 ± 0.72% moisture for FG and IG, respectively.

Instrumental texture

Figure 1 presents the force–distance curves obtained in FG and in IG zero-day. In each one can be observed the linear increase of the force, whose slope corresponds to elasticity module (ε). In both, a peak is also seen, which corresponded to the epidermis breaking point or F_{max}. The line after some recovery has homogeneous force values corresponding to F_{pulp}. Figure 2 presents F_{max}, F_{pulp} and ε behavior over time.

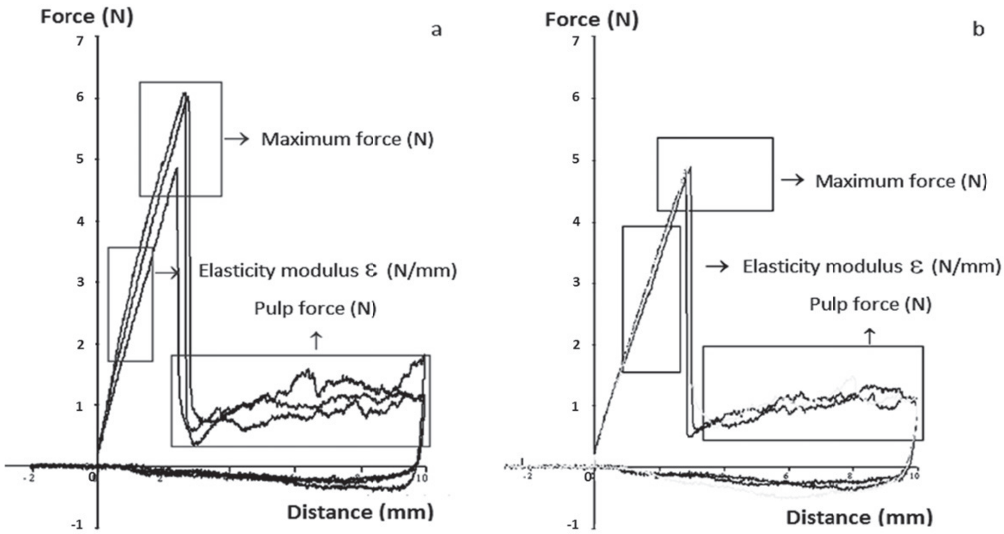

Figure 1. Gooseberries texture curves (a) FG, and (b) IG zero-day.

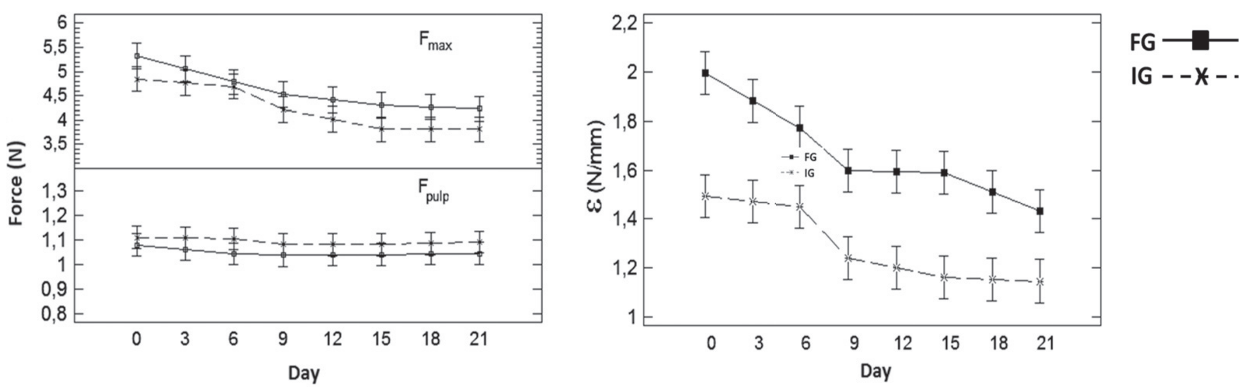

Figure 2. F_{max}, F_{pulp} and ε analysis in FG and IG during storage at 4°C.

It is appreciated that for VI effect, F_{max} decreased significantly, and therefore the product became more elastic; i.e., ε values recorded were statistically lower in IG that in FG. F_{pulp} did not show statistical differences by treatment, but the average values of IG were slightly higher; this short difference indicates that impregnation with weak gelation agents contribute to the pulp strength. By time effect, both IG and FG showed statistical differences in F_{max} and ε, with decreasing tendency. F_{max} in both treatments presented the same homogenous groups ($p < 0.05$): 0 - 6 days; 9 - 21 days; while ε presented four groups in FG (0 - 3, 3 - 6, 6 - 15 and 9 - 21 days) and two in IG (0 - 6 and 9 - 12 days).

Color

Figure 3 shows the evolution of the green-red chromaticity (a^*), yellow-blue chromaticity (b^*), hue (h_{ab}^*), the luminosity L^* and saturation or intensity of color (C_{ab}^*) for storage at 4°C, in the peduncle (IP → impregnated gooseberry peduncle and FP → fresh gooseberries peduncles) and in the equatorial zone of the FG and IG.

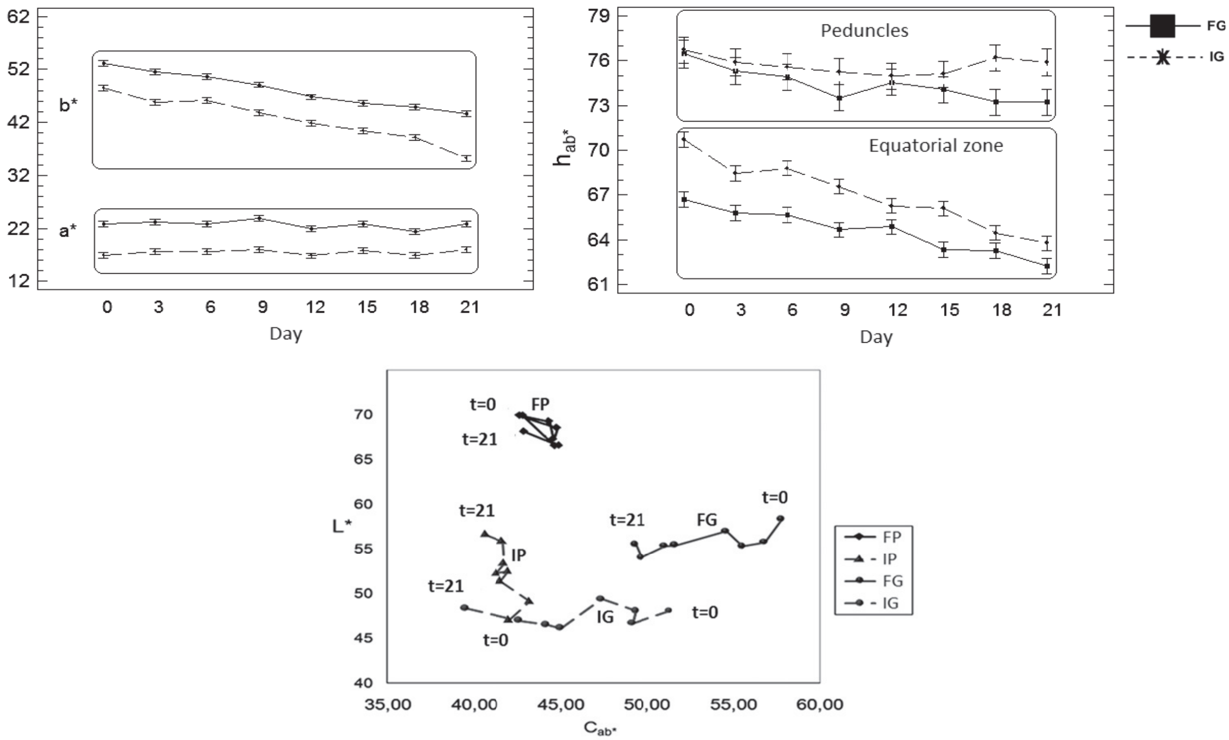

Figure 3. Evolution of color parameters a*, b*, h_{ab}*, L* y C_{ab}* in peduncle (FP and IP) and in equatorial zones (FG and IG) during storage at 4**°C**.

There were significant differences ($p < 0.05$) for VI effect, in all color parameters. The equatorial zone and peduncle of IG showed lower values for a^*, b^*, L^* and C_{ab^*}, and higher values for h_{ab}^* that FG (see figures 3 and 4). By time effect, there were differences in b^*, C_{ab^*} and h_{ab}^* parameters in the equatorial zones of FG and IG, and there were differences too in L^* of the IP. The FP had no significant changes in color parameters during storage.

Sensory evaluation

Figure 4 shows the sensory profile of FG and IG in their general appearance, texture, odor and taste at zero, 18th and 21st storage day. For VI effect there were not significant differences ($p > 0.05$) in the general appearance variables: color uniformity, brightness, spherical shape homogeneity, fungi presence, smooth surface, cracks presence, clefts presence, dried peduncle; but showed significant differences ($p < 0.05$) in orange color, surface stains, fresh look, uniform peduncle, outgoing peduncle and dehydrated appearance. Over time, significant statistical differences ($p < 0.05$) were found in: fresh look, uniform peduncle, clefts presence and dried peduncle.

The odor profile showed no significant differences ($p > 0.05$) in the descriptors: acid, mature, sweet, fruity, floral, herbal, strange, ferment, overripe, fungi and gooseberry characteristic odor by effect of VI and time. Ground odors and aromatic descriptors presented significant differences ($p > 0.05$) over time. The taste profile did not present significant statistical differences ($p > 0.05$) in the descriptors: acid, bitter, ferment, floral, green, herbal, citrus, aromatic, astringent and fungi by effect of VI and time; but showed differences in sweet taste by VI effect (higher score in IG), and by time in gooseberry and fruity characteristic descriptors (loosing taste). For VI effect, texture profile results showed significant statistical differences ($p < 0.05$) in juiciness and firmness, but did not in fleshiness, softness, crunchiness, chewiness, turgor and oily feeling (mouth coating).

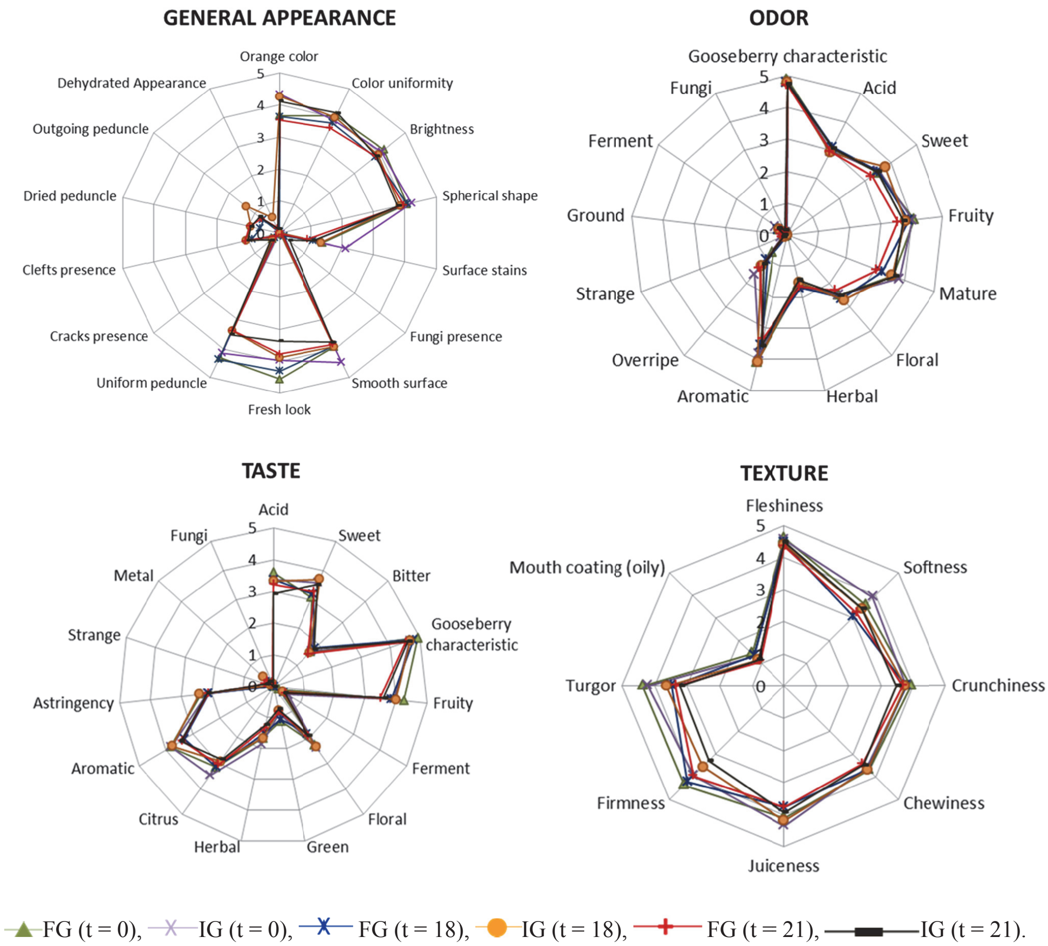

Figure 4. FG and IG sensorial profile by multidimensional approximation.

For time effect there were statistically differences ($p < 0.05$) in softness, juiciness, firmness and turgor descriptors, results that are related with those obtained by instrumental techniques (F_{max} and moisture). Table 2 presents the quality average score of FG and IG. The ANOVA reported significant differences in general quality by both VI and time effects; where the higher values were obtained in FG and at zero-day. All dates corresponded to a high quality, except for IG on 21[st] day that correspond to a medium quality.

Table 2. General quality of FG and IG in storage at 4°C.

Product	Storage (day)	Score
FG	0	2.9
	18	2.6
	21	2.4
IG	0	2.6
	18	2.4
	21	2.2

DISCUSSION

Physicochemical properties

Some authors have reported similar values in FG (2, 10, 22, 42, 43). In all parameters it was observed that IG average values are slightly higher than those of FG, due to the IE coming into gooseberries porous, as water-based emulsion provides 18% w/w soluble solids of sugars, salts and organic acids, among other components. However, due to low incorporated liquid quantity, physicochemical parameters are absorbed by standard deviations.

Instrumental Texture

Similar trends in texture were found by Botero, 2008 (23) and Ciro *et al.*, 2007 (44), while Marin *et al.*, 2011 (21), found no significant differences in F_{max} during storage for impregnation with probiotics. Restrepo *et al.*, 2009 (22), found significant differences in F_{Pulp} by effect of VI, due to the hydrodynamic mechanism that leads to structural changes caused by pressure changes (45). Botero, 2008 (23), found no significant difference in ε, his value is lower than that obtained in the present study, although no gelling agents were used in the IE, which helps to improve the texture. In general, fruits present mechanical properties such as viscous flow and elastic solid jointly (46). Its texture changes are mainly caused by water loss and the hydrolysis of starch, pectin and other cell wall components by enzymatic ways (47, 48), additionally, cape gooseberry is characterized by its high pectinases content (49).

Adding calcium via VI has improved the texture of some fruits, given the interaction with pectic components of the cell wall (50-52); however, the decrease of ε and F_{max} in the IG might be attributed to multiple factors: ripening process (2), the increase of moisture in the epidermis due to IE (21, 22), the hydrodynamic mechanism and relaxation phenomena caused by the pressure changes that the fruit experiences during the VI process (53).

Instrumental color

L^* values decreasing by treatments are attributed to IE presence on intercellular spaces or pores, which makes the refractive index more uniform, thus enhancing the light absorption in surface, therefore impregnated samples are seen darker than the untreated ones. Some research has found similar results in impregnation processes, for example, green banana impregnated with antipardeants (54), celery and cucumber impregnated with vitamin E (55), cape gooseberry impregnated with *Lactobacillus casei* (56), apple impregnated with lactic acid bacteria (57) and apple impregnated with vitamin E (58). The gradual increase of L^* in IP during storage is attributed to IE mobility from this area to the interior of the fruit, a behavior that was also found by Marín, 2008 (59).

Decreasing b^*, h_{ab*} and C_{ab*} values over time are associated with the red and yellow pigments dilution in the IE and with physiological changes during fruit ripening. Similar behaviors in color parameter were found by some authors after impregnation processes (22, 23); however, other researchers found an increase in chromaticity b^* over time (59).

Sensory evaluation

Few sensorial evaluation studies of impregnated products with PAC have been performed. The effect of VI process on cape gooseberry produces some alterations in the general appearance perceived by the panelists. A greater perception in the intensity of the orange color is due to the incorporation of the EI in the intercellular spaces of the fruit, which is coherent with the aforementioned instrumental results (figure 3). Similar results have been found in the sensorial assessment of cape gooseberry and strawberries impregnated with vitamin E (60), and cape gooseberry impregnated with *L. Plantarum* and *L. Casei* (61). The uniformity of color in the recently impregnated cape gooseberries was similar to the FG; however, during storage the scores of IG tend to better values than those presented by FG, which is attributable to the diffusion of the EI from the intercellular spaces (close to the peduncle) to the interior of the fruit, which is in turn coherent with the instrumental measure up to day 15th, where the Δh_{ab}^* (peduncles – equatorial zone) in the IG is lower than the FG, for each control time. The sensorial perception of superficial stains in FG samples is spontaneous, where the peduncle zone is much more bright (L^* >>) than the equatorial (L^* <<), the maximum score of this descriptor did not surpass the magnitude of 2.5, but is greater in the peduncle surrounding zone of the IG at time 0 (equally consistent with the instrumental results), and during storage decrease. The fresh appearance of the FG and IG showed a decrease with time, which is consistent with the increase of dehydrated appearance score, due to the fruit's physiology (62, 63). The cicatrization appearance in the peduncle surrounding is present in both samples, with scores below 1.5, but the VI process may induce to fissures because of the stress caused by the pressure changes throughout the process. The presence of clefts, although being of minor concern, may be related with the dehydration of the fruit during its respiration process (62, 63).

In both samples the greater intensity of the odor descriptors was found in cape gooseberry characteristic, frutal, aromatic, acid, sweet and ripe, tending to keep its score throughout the time, expect by the aromatic odor which decrease due to the physiological process of ripening during storage, appearing losses in volatile compounds, as well as color changes, texture and taste (62, 63). The averages of sweet odor score were greater in the IG samples than in FG, because of the resulting impregnated sucrose in the waxy layer of the fruit.

The greater intensity of the taste descriptors was found in cape gooseberry characteristic, frutal, aromatic, acid and sweet. The sucrose content of EI confers a greater perception of sweetness in the IG than in the FG, keeping constant over time. Similar results have been found in apple, cape gooseberries and strawberries impregnated with vitamin E (20, 60), in cape gooseberry impregnated with probiotic microorganisms (61) and orange skin (64). In the FG the score of cape gooseberry characteristic taste and the frutal taste decrease with time, whereas for the IG decrease the herbal taste and critic, which may be equally attributable to the biochemical process of ripening, and also to the decreasing of its acidity over time, that induce a decrease in the acidity-sweetness balance and a more noticeable difference in the perception of taste than at time 0. The strange, metallic and fungi taste were not relevant descriptors during the sensorial assessment.

In general, the descriptors of texture have a tendency to decrease its score with respect to time, being more relevant the soft texture, juicy, firmness and turgidity. The physiology of the fruit ripening in both FG and IG plays a very important role in the texture, which was consistent with the instrumental results (figure 2).

CONCLUSIONS

The VI process does not significantly affects the physicochemical properties of the fruit, but changes in physical properties like color and texture were observed through the instrumental analysis. The IG samples present lower red chromaticity (<<< a^*), lower yellow chromaticity (<<< b^*), lower color saturation (<<< C_{ab}^*) and are darker (<<< L^*) than FG samples; besides, they are softer (<<< F_{max}) and more elastic (<<< ε). The descriptors of greater intensity in the sensorial assessment of both samples were: orange color, brightness, spherical uniformity, smooth surface, fresh appearance, odor and cape gooseberry characteristic taste, frutal taste, firmness, fleshy texture and juicy. The VI process produces significant changes in the sensorial perception of the cape goosberry, mainly by conferring a greater intensity of orange color and superficial stains, less fresh appearance, greater sweetness, less cape gooseberry characteristic taste, softer texture, less firmness and juicy; whereas for effect of storage time there is a sustenance of the orange color, and changes mainly due to decrease of the fresh appearance, decrease of superficial stains, increase in the peduncle cicatrization and cleft presence, decrease in frutal odor and taste, softer texture and decrease of juicy and firmness. The general quality of the FG exhibited a greater score than the IG.

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