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An analysis of the postharvest behavior of four genetic materials of feijoa (*Acca sellowiana* Berg)

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Abstract - The characteristics of four genetic materials of feijoa (GM7, GM12, GM26, and GM27) after 7, 15, and 30 days of refrigerated storage (5°C and 97% RH) followed by 7 days of shelf-life (20°C and 80% RH) were analyzed. Respiratory activity, weight loss, flesh firmness, external and internal color, internal browning, total polyphenol content (TPC), and total antioxidant capacity (TAC) were determined. GM12 exhibited the best respiratory activity in most of the evaluated moments. Significant weight loss, i.e., 5%–7% of the initial weight at 7+7 and 15+7 days of storage and 8%–10% at 30+7 days was observed, especially in GM26. At harvest, flesh firmness was 38–57 N and reduced by 50%–65% in shelf-life. The external color did not show noticeable differences. Internal browning, which increased with the storage progress, was less noticeable in GM7, possibly owing to its lower TPC and TAC. GM26 and GM27 were the least firm and had the maximum weight loss. Although GM7 had a lower content of functional compounds, it had less internal browning. GM12 presented significant respiratory activity, high content of functional compounds, and acceptable firmness retention and weight loss, making it the most promising genetic material analyzed in this study.

Index terms: respiratory activity, flesh firmness, internal quality, functional compounds.

Uma análise do comportamento pós-colheita de quatro materiais genéticos de goiaba-serrana (*Acca sellowiana* Berg)

Resumo - O comportamento de quatro materiais genéticos, durante 7; 15 e 30 dias de armazenamento refrigerado (5°C e 97% UR), seguido de 7 dias de vida de prateleira (20°C e 80% UR), foi analisado. Determinaram-se a atividade respiratória, a perda de peso, a firmeza da polpa, as cores externa e interna e o escurecimento interno. Além disso, foram os teores de polifenóis totais (PT) e a capacidade antioxidante total (CAT). Foram encontradas diferenças na atividade respiratória, onde o MG 12 atingiu os maiores valores, na maioria dos momentos avaliados, e o climatério respiratório, aos 7 dias após o armazenamento. A perda de peso mais significativa foi alcançada no período de vida de prateleira (5-7% do peso inicial) em 7+7 e 15+7, respectivamente, e entre 8-10% em 30+7 dias. O MG 26 apresentou maior

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percentual de perda de peso. No momento da colheita, a firmeza da polpa estava entre 38 e 57 N, reduzindo-se entre 50-65% na vida de prateleira. A cor externa não apresentou diferenças perceptíveis entre MG. Algum escurecimento interno foi observado, o que aumentou com o avanço do armazenamento, sendo menos perceptível no MG 7, o que pode estar relacionado ao seu menor teor de PT e CAT. Foram encontradas diferenças entre os MG, onde o 26, junto do 27 apresentaram menos firmeza, e, no caso do 27, a perda de peso foi mais significativa. Apesar de que o MG 7 apresentou menor teor de compostos funcionais, foi o de menor escurecimento interno. Embora o MG 12 tenha apresentado atividade respiratória mais elevada, teve alto teor de compostos funcionais e aceitável retenção de firmeza e de perda de peso, o que o coloca entre os mais promissores.

Termos para indexação: atividade respiratória, firmeza da polpa, qualidade interna, compostos funcionais.

Introduction

Feijoa (*Acca sellowiana* Berg) belongs to the Myrtaceae family. It is native to South America and grows mainly in Uruguay, in the southern part of Brazil, and is in some regions of Paraguay and Argentina (PARRA-CORONADO; FISCHER, 2013). In other regions of the world, especially New Zealand, it is a fairly established commercial crop, developed based on genetic materials collected from Uruguay and Brazil. In Uruguay, its domestication began in 2000, and there are currently released varieties. Studies have been conducted to identify the genetic materials of interest, including the characterization of their postharvest behavior in addition to agronomic aspects. The harvest period of feijoa extends from March to May. The feijoa fruit of different genetic materials has essential differences in their metabolic and physicochemical characteristics that directly affect the fruit's postharvest quality, thereby warranting investigations on their characterization.

In regard to general characteristics, feijoa is a climacteric fruit. A few studies indicate that it is sensitive to cold with and storage period of 21 days at 4°C with a shelf life of 2 days (AMARANTE et al., 2008; VELHO et al., 2011). Increased storage periods lead to a decrease in fruit quality, evidenced by the loss of flavor, due to changes in acidity and sugars, and by the occurrence of darkening of the pulp (AMARANTE et al., 2013). This is another crucial aspect of being considered within the selection programs.

Although the concept of the consumption of health-beneficial compounds by fruit and vegetable intake is well-established, in recent years, more attention has been paid to them as their regular consumption may help prevent a range of diseases (LORENZO et al., 2021). Antioxidants in fruits, especially phenolic compounds, act as reducing agents against reactive oxygen species, often generated as byproducts of biological reactions or in response to exogenous factors. These reactive oxygen species can disrupt cells structure by reacting with proteins, lipids, carbohydrates, and nucleic acids (MELO et al., 2008; AMARANTE et al., 2017b). Feijoa fruits have attracted scholarly interest due to their composition, related to phenolic compounds, vitamins, and others with antibacterial, anti-inflammatory, antioxidant, and anti-allergic activity, and their sweet-acid flavor and characteristic aroma (ZHU, 2018).

In this study, we aimed to evaluate the behavior of four genetic materials (GM7, GM12, GM26, and GM27) during refrigerated storage and subsequent shelf life to contribute to developing new varieties of feijoa that can be commercially exploited.

Material and methods

Vegetable material

The fruit came from trees in full production (about 7 years old) of a commercial orchard situated in Progreso Canelones Department in Uruguay (34°40’02.5”S 56°13’03.3”W). The genetic materials corresponded to the following trees: GM7 (Toribio Fros 1, Laureles); GM12 (FI Ca 336, Salto Grande); GM26 (Río Negro 4, Isla de los Naranjos); and GM27 (Río Negro 5, Isla de los Naranjos). The harvest was carried out at the end of March, and harvesting yielded developed fruits that did not detach themselves from the tree (in a state prior to touching–picking). This stage has been defined in a previous study (SILVEIRA et al., 2015).

After harvesting, fruits were transported to the Poscosecha de Frutas y Hortalizas laboratory (Facultad de Agronomía, Uruguay), selected, placed in 1-kg polypropylene trays, and stored at 5°C and 97% RH. Different analyses were conducted immediately after harvest and after 7, 15, and 30 days of refrigerated storage. Fruit characteristics in shelf-life conditions (20°C and 80% RH) for 7 days after each storage output were also analyzed. Thus, final analysis included fruits with a total of 7+7, 15+7, and 30+7 days of storage. The characteristics were measured as follows.

Respiration rate

Respiration rate was measured by gas chromatography using the static method. Fruits (4 of ~120 g) were weighted and placed on clean 1-L glass jars with a silicon septum on the lid to extract the gas sample of head space that allowed for hermetic closure. At each determination stage, glasses were closed for 1 h. Afterward, gas samples were collected using a disposable syringe and injected into a gas chromatograph (Agilent Technologies 7890B, CG System, Santa Clara, USA). This device was equipped with a packed 80/100 column (Agilent, HayaSep T, Santa Clara, USA), 3.66 m long and 2 mm in internal diameter. High-purity nitrogen was upgraded as a carrier gas (Linde, Montevideo, Uruguay) with oven, detector, and injector temperatures of 100°C, 300°C, and 60°C, respectively. Four repetitions (jars) were assayed, and values were reported as mg CO_2 kg^{-1} h^{-1}.

Weight loss

For weight loss determination, the fruits were weighed at the harvest and in each evaluation stage (refrigerated storage and shelf life) using a digital scale (Acculab, VI-10 kg, Vernon Hills, USA). Three repetitions corresponding to the trays with seven fruits were measured, and the results were expressed as a percentage of the initial weight.

Flesh firmness

Flesh firmness was measured in terms of the compression in the equatorial zone of a whole fruit using a texture analyzer (Stable Micro System, TA. XT Express, Godalming, UK) using a stainless steel plate of 75 mm diameter that descended at a speed of 1 $mm.s^{-1}$ and compressed the fruit 2 mm. Twenty-one fruits were measured during each evaluation stage for each genetic material, and values were expressed in N.

External and internal color

The color was measured on the equatorial zone of the fruit using a colorimeter (PCE Ibérica, TCR 200, Albacete, Spain). The parameter luminosity (L*) hue (h_{ab}) and Chroma (C^*_{ab}) were determined in 21 fruits in each genetic material and evaluation stage.

The internal color was determined using the same equipment used to measure external color. Fruits were half cut for the equatorial zone, recording the values immediately after 5 and 10 min. At each evaluation stage, a visual assessment was made using and scale of 5 points, where "1" corresponded to *non-browning* and "5" to a *very high browning*. Measurements were made in 15 fruits in each genetic material and at each evaluation stage.

Browning index

The browning index (BI) was determined using the methodology described by Cefola et al. (2012) using the following equations:

$$BI = \frac{100\,(x - 0{,}31)}{0{,}17} \quad X = \frac{a{*}t + 1{,}75\,L{*}t}{5{,}645L{*}t + a{*}0 - 3{,}012b{*}t}$$

The parameter a*0 was measured after the cut, and a*t, L*t, and b*t corresponded to that measured 10 min after the cut.

Total polyphenol content

To measure the total polyphenol content (TPC) 1 g of flesh (Liang Ping, FA/JA Series, China) was homogenized (Labotech Scientz, XHF-D, Zhejiang, China) with 3 mL of methanol 70% (Merck KGaA, Darmstadt, Germany) at 28,000 rpm during 15 s and then centrifuged (Thermo Scientific, Sorvall ST16/ 16R, Osterode am Harz, Germany) for 10 min at 4°C and 15,000 *gx*. After that, the methodology proposed by Singleton and Rossi (1965) was adopted. An aliquot of 19.2 µL was added to 29 µL of Folin reactive 1:1 (v/v), and after 3 min, 192 µL of 0.4% sodium hydroxide and 2% sodium carbonate solution were added. Absorbance was measured at 750 nm after 30 min incubation in a microplate reader spectrophotometer (Thermo Scientific™ Multiskan SkyHigh, Madrid, Spain). Results were expressed in mg gallic acid equivalent in fresh weight (mg GAE 100 g^{-1} FW).

Total antioxidant capacity

The total antioxidant capacity (TAC) was determined using the same extract used for TPC determination. After the extraction, an aliquot of 21 µL was mixed with 194 µL of a solution 0.1 mM of 1,1-diphenyl-2-picrylhydrazyl (DPPH) according to Brand William's et al. (1995) methodology with slight modification. Samples were incubated for 0.5 h in the dark, and absorbance was measured at 515 nm in a microplate reader spectrophotometer (Thermo Scientific™ Multiskan SkyHigh, Madrid, Spain). The results were expressed in mg ascorbic acid equivalent (mg AAE 100 g^{-1} FW).

Statistical analysis

A complete randomized design was established. When significant differences were found in the analysis of variance, the values were analyzed with a Tukey comparison of means ($P \leq 0.05$). Data were analyzed using the statistical program Infostat version 2021 (Universidad Nacional de Córdoba, Córdoba, Argentina).

Result and discussion

Respiration rate

Differences in the respiratory characteristics between the four genetic materials were found, and the findings are depicted in Figure 1. In most of them, an initial high value was observed immediately after harvest (between 30–50 mg CO_2 $kg^{-1}h^{-1}$) with a subsequent fall to almost half, following the characteristic behavior consequent to the stress determined by the harvest. The climacteric peak was observed after 5 days on GM27 and after 7 days on the other genetic materials. GM12 showed a higher respira-

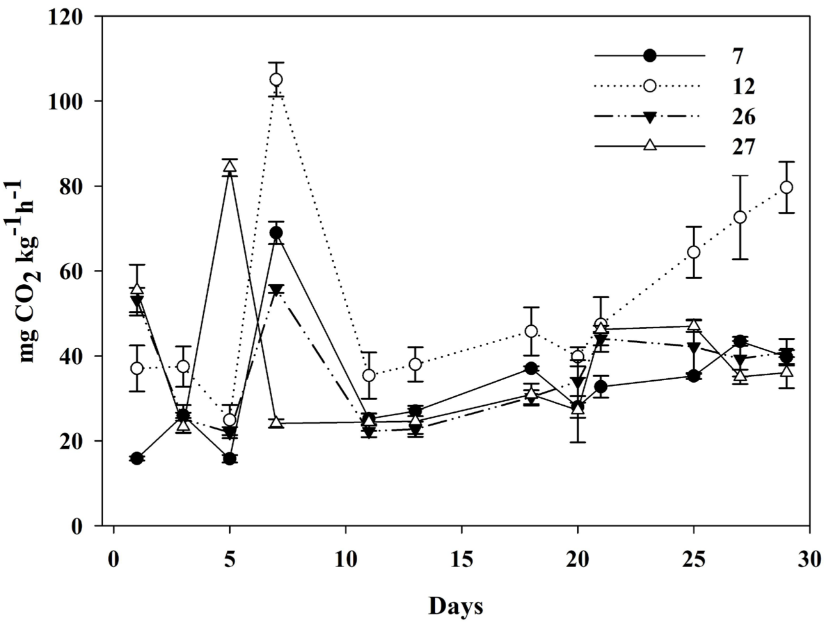

Figure 1 - Respiration rate of feijoa fruit stored at 5 ºC for 30 days expressed as percentage (mg CO_2. kg^{-1}. h^{-1}). Vertical bars indicate the standard error of the means (n = 4).

tion rate in most of the evaluation moments. It showed a sustained increase at the end of the storage period, possibly owing to the onset of senescence. The remaining materials did not differ from each other and showed relatively stable respiration after the climacteric peak until the end of storage.

In Harman's (1987) study, the feijoa fruit achieved the climacteric minimum about 90 days after anthesis with 20–30 mg CO_2. kg^{-1}. h^{-1}. They noted that the respiration rate increased after harvest, about 110 days after anthesis, and during the postharvest period. East et al. (2009) evaluated the postharvest behavior of 'Unique' feijoa fruit stored at 5°C for 56 days and reported a respiration rate variation between 22 and 29 mg CO_2. kg^{-1}. h^{-1}, with the lower values registered at the beginning of the storage. More recently, Urraburu et al. (2018) reported that the respiratory activity of feijoa fruit of different genotypes stored at 5°C for 30 days was between 20.7 and 30.3 mg CO_2. kg^{-1}. h^{-1}. Therefore, the climacteric peak and values obtained in this study are in the range of those reported by other authors who made evaluations under similar conservation conditions.

Weight loss

During the refrigerated storage, weight loss initially remained roughly constant but increased after 15 days. It almost doubled after 30 days, about 4.5%–5% of the initial weight (Figure 2). The maximum weight loss occurred during the shelf-life period, with values of about 5%–7% of the initial weight, on fruits from 7 and 15 days and 8%–10% on those from 30 days of storage. The differences were also found after 15 days of storage, where GM26 showed the higher weight loss. During the shelf-life period, the main differences occurred in 15+7, where the lowest weight loss was observed for GM7, and in 30+7, where GM26 had the lowest weight loss.

According to Hoffmann et al. (1994), weight loss of feijoa fruits at room temperature reached 5.5% of the initial value in less than a week. In refrigerated storage, weight loss was 10.63% after 21 days at 2°C and 16.2% after 28 days. These values were slightly higher than those found in our study, mainly because at 2°C, feijoa fruits could show chilling injury. After 2 days at room temperature, weight loss of 3.8% and 2.8% was found in fruits stored for 21 and 28 days, respective-

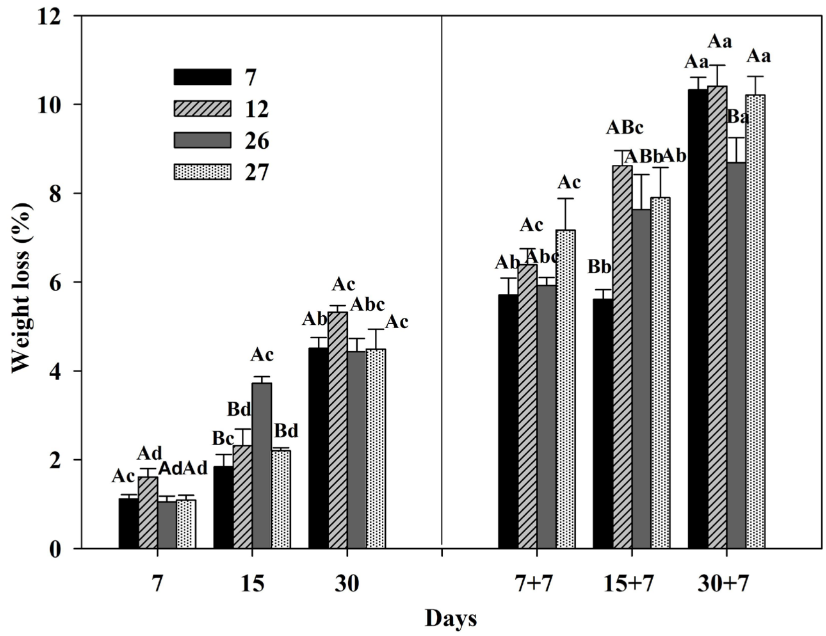

Figure 2 - Weight loss of feijoa fruit stored at 5°C for 30 days followed by 7 days at 20 °C. Vertical bars represent standard error of the means (n = 3). Means followed by different letters, uppercase for GM in each moment and lowercase for storage time in each GM, are statistically different according to Tukey test at p ≤ 0.05.

ly. In this case, the losses were lower than those registered in our work but correspond to a shorter shelf-life period. On the other hand, Amarante et al. (2017a) evaluated five genotypes and found 4% of weight loss in the feijoa fruit stored 21 days at 4°C and 90% RH. As observed in this study, the highest percentage of weight loss was recorded in shelf-life, about 30% after 2 days at 23°C and 75% RH.

In general, weight loss results from the vapor pressure differences between the fruit and the surrounding atmosphere in the heat transfer process that occurs during cooling. Heat is transferred primarily by the temperature difference between the product and the atmosphere to which respiration, where various substrates are oxidized to generate energy, contributes (LU et al., 2013). Consequently, the weight decreases over the storage time and has undesirable effects on its quality. This weight loss can be fairly significant when the water activities between the product and the surrounding atmosphere are large or when the storage time is long (CASTELLANOS et al., 2016). In a study carried out by these authors, a linear weight loss at the different temperatures evaluated (6°C, 12°C, and 18°C) was noted. At 7 days of storage, it was 2–3 times higher in fruits stored at 18°C compared with those kept at 6°C.

Flesh firmness

At harvest moment, flesh firmness was 38–57 N (Figure 3). On 7 and 15 days of refrigerated storage, a decrease of 35% was observed. After 30 days of storage, flesh firmness was reduced to 50%–65% of the values measured at harvest. Also, in this case, the most significant losses corresponded to the shelf-life period with values between 50% and 70%, regardless of the refrigerated storage time. In general, GM26 and GM27 were firmer than GM7 and GM12, which did not differ from each other.

Al-Harthy et al. (2010) reported that 'Unique' feijoa fruit showed an accelerated decrease in firmness, going from around 14 N after 4 weeks to around 7 N after 10 weeks of storage in air at 4°C. After 7 days of shelf-life (20°C), the firmness reached half the value it had when leaving storage. The authors also reported a relationship between firmness and the structure and composition of the cell wall, as well as the water status or tur-

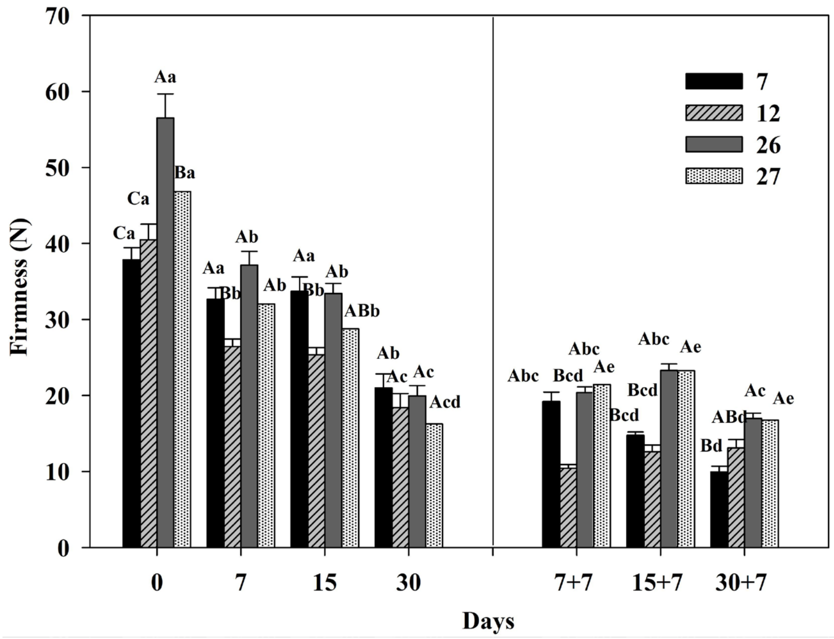

Figure 3 - Flesh firmness of feijoa fruit stored at 5°C for 30 days followed by 7 days at 20 °C. Vertical bars represent standard error of the means (n = 21). Means followed by different letters, uppercase for GM in each moment and lowercase for storage time in each GM, are statistically different according to Tukey test at p ≤ 0.05.

gor pressure in the cells, which showed that there was a relationship between weight loss and fruit firmness, and while weight loss increased, firmness decreased. In a work of genotype evaluation carried out by Amarante et al. (2013), flesh firmness, measured as compression, varied between 37.3 and 105.5 N at harvest and after 21 days of storage at 5°C, followed by 2 days at room temperature, when the values reached to 26.7 and 54.4 N, respectively. In addition, when five genotypes were analyzed, differences were found at harvest with values between 50, 42, and 78, reducing between 34% and 49.5% after 21 days at 4°C followed by 2 days at room temperature (AMARANTE et al., 2017b). This shows that fruit texture deteriorates substantially as the fruit ripens (RUPAVATHARAM et al., 2015; AMARANTE et al., 2017b). The results of this work are consistent with those found by these authors.

External color

The external color did not exhibit significant variations both during refrigerated storage and shelf-life. Also, no notable differences in terms of external color between the genetic materials analyzed were detected. The luminosity remained constant without significant variations during refrigerated storage. However, an increase was observed after 7 days of shelf-life after 30 days of storage (Table 1). The lowest L* value corresponded to GM12.

The parameter h_{ab} was unaffected by the storage time and did not show differences among different genetic materials, presenting values between 113 and 117 corresponding to a green coloration. At the end of the shelf-life, there was a reduction in h_{ab}, which passed to values between 104 and 109, indicating a yellowish-green coloration due to chlorophyll degradation

Table 1- External color parameter of four feijoa GM during refrigerated storage (5°C, 97% RH) and in shelf-life period (20°C, 80% RH).

Genetic material		7	12	26	27
Luminosity	Harvest	[abc] 43.83 ± 0.86 ABb	42.78 ± 0.68 Ba	45.79 ± 1.06 Abc	45.67 ± 0.56 ABbc
	7 days	44.22 ± 0.82 ABb	42.35 ± 0.69 Ba	46.56 ± 0.81 Aabc	45.17 ± 0.79 ABbc
	15 days	43.33 ± 0.94 Bb	43.27 ± 0.52 Ba	48.42 ± 0.81 Aab	45.37 ± 0.91 Bbc
	30 days	45.88 ± 0.96 BCb	43.17 ± 0.61 Ca	49.16 ± 1.12 Aab	48.01 ± 0.85 ABabc
	7+7 days	45.36 ±0.91 Ab	44.84 ± 0.82 Aa	44.07 ± 1.01 Ac	44.92 ± 0.94 Ac
	15+7 days	52.61 ± 0.95 Aa	44.61 ± 0.77 Ca	46.96 0.93 ± Babc	48.35 ± 0.74 Bab
	30+7 days	51.51 ± 1.02 Aa	43.31 ± 0.56 Ba	49.55 ± 1.05 Aa	49.36 ± 0.76 Aa
hue_{ab}	Harvest	115.34 ± 0.71 Aabc	117.16 ± 1.05 Aa	116.31 ± 0.36 Aa	115.39 ± 0.73 Aa
	7 days	117.05 ± 0.73 Aab	115.89 ± 0.88 Aab	114.43 ± 0.57 Aa	115.39 ± 0.73 Aa
	15 days	117.38 ± 0.76 Aa	117.43 ± 0.66 Aa	114.88 ± 0.91 ABa	113.54 ± 0.65 Bab
	30 days	113.61 ± 0.97 Abc	115.89 ± 0.78 Aab	114.82 ± 0.63 Aa	113.83 ± 0.67 Aab
	7+7 days	112.91 ± 0.79 ABc	113.16 ± 0.64 ABb	114.46 ± 0.56 Aa	111.14 ± 0.61 Bbc
	15+7 days	106.23 ± 0.87 Bd	108.77 ± 0.69 Bd	112.88 ± 0.62 Aa	108.69 ± 0.64 Bc
	30+7 days	104.39 ± 1.46 Bd	109.52 ± 1.05 Ad	109.24 ± 1.07 Ab	107.78 ± 2.04 Ac
ΔE	Harvest	-	-	-	-
	7 days	2.81 ± 1.01 b	2.24 ± 0.62	4.22 ± 0.77	1.51 ± 0.48
	15 days	3.99 ± 0.91 b	2.31 ± 1.03	5.62 ± 1.28	4.36 ± 2.19
	30 days	3.58 ± 0.35 b	2.96 ± 1.04	5.84 ± 0.68	2.61 ± 1.23
	7+7 days	5.63 ± 1.12 b	3.31 ± 1.29	5.61 ± 1.84	5.25 ± 2.12
	15+7 days	14.11 ± 2.19 a	6.31 ± 1.1	3.92 ± 1.38	6.24 ± 1.74
	30+7 days	10.13 ± 2.87 a	4.91 ± 0.29 NS	8.85 ± 1.97 NS	5.59 ± 2.8 NS

a Values are means ± standard error of the means (n = 20)

b Means followed by different letters, uppercase and lowercase for column and row (luminosity and hue ab), are statistically different (Tukey test at p ≤ 0.05).

c Means followed by different letters for ΔE of each genetic material, are statistically different according to Tukey test at p ≤ 0.05.

linked to the advancement of the maturation process. The C^*_{ab} values remained practically unchanged during refrigerated conservation (between 19 and 23), presenting a slight increase during shelf -life where they ranged between 22 and 33 (data not shown). The minor variation in the color of the guava fruits is evidenced in the parameter ΔE, where, except for GM7, the color did not suffer variations detectable by the human eye during the entire conservation period. In the case of GM7, color variations were only perceptible at 15+7 and 30+7 days of storage and shelf life.

According to Parra-Coronado and Fischer (2013), feijoa fruits are olive green and do not change color drastically as they ripen. However, some cultivars evolve from dark green to light green during maturation. Al-Harthy et al. (2010) indicated that in 'Unique' feijoa fruit, there was no significant difference in the color of the skin neither in the fruits kept in the air nor those kept under controlled atmosphere conditions after 10 weeks of storage and 1 week of shelf-life. Moreover, Amarante et al. (2017a) reported a reduction in the L* values in 'Alcântara', 'Helena', and 'Mattos', which was accompanied by a reduction in C^*_{ab} in 'Helena' and in h_{ab} in 'Mattos'. Therefore, it can be said that the color remained without significant variations after 21 days of conservation at 4°C, since the few changes observed were practically imperceptible to the naked eye.

Internal color and browning index

Color parameters L* and h_{ab} did not show differences when measured immediately after cutting or after 5 and 10 min, so only the values measured at 10 min are presented herein (Table 2). The L* parameter showed differences where, in general, the highest values corresponded to GM7. Regarding the evolution over time, in GM7 and GM26, a decrease was already registered at 7 days, whereas in GM12 and GM27, the decrease occurred from the 15th day. However, the most remarkable differences occurred between the values measured at harvest versus those measured at 15+7 and 30+7 days. Concerning the h_{ab}, differences were also found between the GM, where GM7 presented the highest values. During refrigerated storage, the values remained relatively stable while there was a reduction during the shelf-life, where the color changed from whitish to reddish-brown. Not noticeable changes were observed in C^*_{ab} values, which were kept between 14 and 20 (data not presented herein).

Table 2- Internal color parameter of four feijoa GM during refrigerated storage (5°C, 97% RH) and in shelf-life period (20°C, 80% RH).

Genetic material		7	12	26	27
Luminosity	Harvest	[abc] 62.37 ± 1.26 Aa	42.28 ± 1.07 Cabc	52.76 ± 1.81 Ba	50.22 ± 1.19 Ba
	7 days	55.28 ± 1.91 Abc	46.33 ± 1.72 Ba	42.65 ± 1.51 Bb	46.22 ± 2.02 Bab
	15 days	50.07 ± 1.26 Acd	41.19 ± 1.27 Cbc	46.19 ± 1.49 ABb	42.45 ± 1.11 BCc
	30 days	51.81 ± 1.02 Abcd	39.70 ± 1.11 Cbcd	46.09 ± 1.49 Bb	44.59 ± 1.21 Bb
	7+7 days	50.85 ± 0.86 Abcd	44.50 ± 1.22 Bab	41.16 ± 0.84 Bb	44.57 ± 1.15 Bb
	15+7 days	56.18 ± 0.84 Ab	35.83 ± 0.79 Cd	44.72 ± 1.31 Bb	41.91 ± 0.98 Bb
	30+7 days	47.41 ± 1.58 Ad	38.41 ± 0.87 Ccd	41.68 ± 1.61 BCb	44.20 ± 1.27 ABb
hue_{ab}	Harvest	93.31 ± 0.44 Aa	78.51 ± 1.88 Cb	86.91 ± 0.52 Ba	87.61 ± 0.81 Ba
	7 days	91.93 ± 1.97 Aab	86.04 ± 0.86 Ba	79.49 ± 1.06 Cb	87.03 ± 0.82 Ba
	15 days	89.19 ± 0.96 Aab	77.37 ± 2.75 Cb	77.33 ± 2.06 Cbc	83.91 ± 1.62 Ba
	30 days	84.03 ± 0.66 Acd	70.31 ± 1.14 Cdc	73.18 ± 0.91 Cc	78.33 ± 1.67 Bb
	7+7 days	85.47 ± 1.01 Ac	78.41 ± 0.75 Bb	74.67 ± 1.42 Bbc	75.97 ± 0.91 Bbc
	15+7 days	87.59 ± 1.05 Abc	67.03 ± 1.18 Cc	76.57 ± 1.28 Bbc	76.31 ± 1.51 Bbc
	30+7 days	79.74 ± 1.39 Ad	69.74 ± 0.50 Bc	66.93 ± 1.20 Bd	71.59 ± 1.56 Bc

a Values are means ± standard error of the means (n = 20)

b Means followed by different letters, uppercase and lowercase for column and row, are statistically different (Tukey test at p ≤ 0.05).

BI and visually browning evaluation exhibited a positive correlation (r = 0.51 p < 0.0001). In both cases, differences were found between the values recorded after the cut and after 10 min, where the highest values were recorded in most of the genetic materials and evaluation stages (Figs. 4 and 5). BI was lower in GM7 during refrigerated storage and at 30+7 days, with no differences found between the other materials. About the evolution of the BI over time, values remained constant (between 40%–60%) until 30+7 days, increasing later with values between 59% and 80% (Figure 4). On the other hand, the visual evaluation carried out at 10 min showed an increase in the browning of GM7 at harvest, 30 days, 15+7, and 30+7, compared to what was observed immediately after cutting (Figure 5).

Internal browning in feijoa fruits has been reported by other authors as associated with cold damage. However, in our

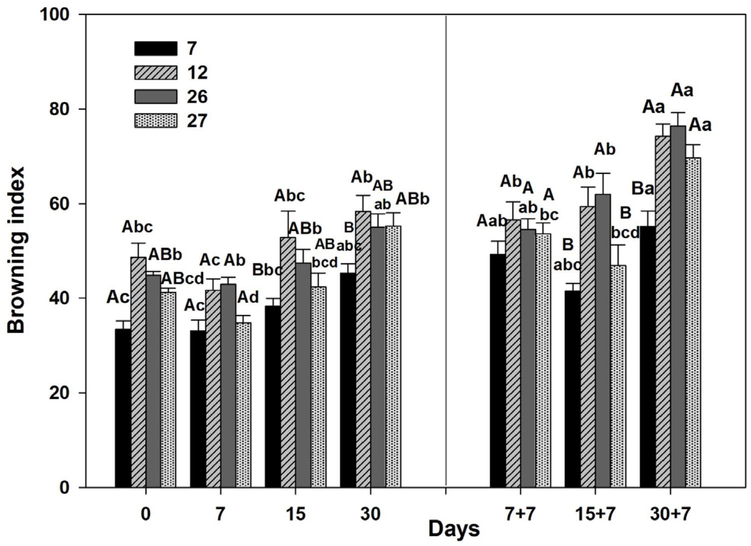

Figure 4 - Browning index of feijoa fruit stored at 5°C for 30 days followed by 7 days at 20 °C, after cut and after 10 min of cut. Vertical bars represent standard error of the means (n = 5).

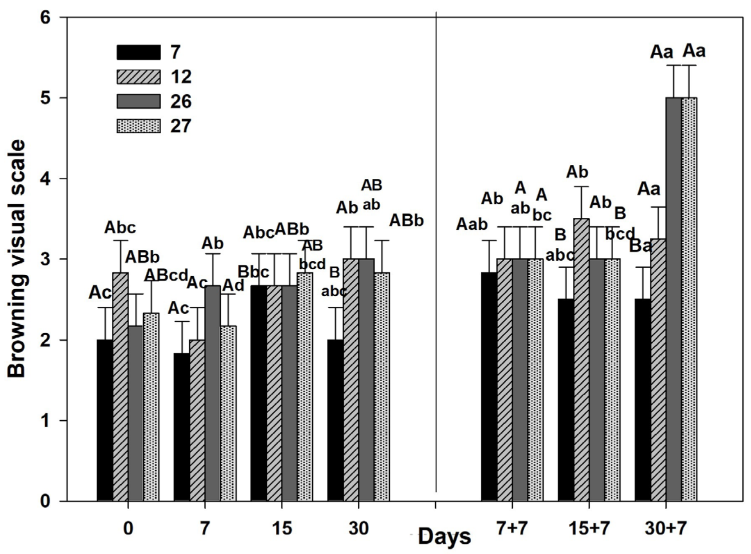

Figure 5 - Browning visual evaluation of feijoa fruit stored at 5°C for 30 days followed by 7 days at 20 °C, after cut and after 10 min of cut. Values are means (n = 5).

study, browning appeared immediately after harvest, so it appeared independent of cold damage and instead associated with the content of polyphenols and enzymes linked to the oxidation and polymerization processes of quinones, forming brown-colored compounds (REYES et al., 2007; MOON et al., 2020). The behavior observed in GM7, which was the material with the lowest content of polyphenols and the lowest BI, would support this hypothesis. Undoubtedly, cold stress, as well as the maturation and senescence process, would increase the occurrence of these reactions by affecting the permeability of the membranes, favoring contact between enzymes and substrates. According to other research groups, cell membrane integrity is closely related to the browning process (LI et al., 2017; LIN et al., 2018).

Total polyphenol content

The analysis showed that GM7 presented the lowest TPC, being around 60 mg GAE 100 g^{-1} FW. This content corresponded to about half of the content found in the rest of the genetic materials, between 90 and 140 mg GAE 100 g^{-1} FW (Figure 6). It was not possible to identify materials with a higher TPC as the differences between them appeared at specifics moments (harvest and 15 days). The evolution during the storage period evidenced that the highest values were found at harvest and up to 7 days of refrigerated storage. In shelf-life, no additional reduction was observed. Although GM7 was the one with the lowest content of polyphenols, it presented the highest retention.

These values were similar to those mentioned by Pasquariello et al. (2015), who reported a wide range with values between 90 and 250 mg GAE 100 g^{-1} FW. However, they were lower than those reported by Amarante et al. (2017b). The latter indicates values between 140 and 180 mg GAE 100 g^{-1} FW, which may be associated with differences in the sample extraction since these authors analyzed the aqueous and hydroalcoholic extracts separately. Phan et al. (2019) reported around 200 mg GAE 100 g^{-1} FW in the pulp of feijoa fruits. Despite the differences in the contents reported in the studies, the values found are within the range. The differences would reflect the strong genetic component mentioned by the different authors as, in all cases, substantial variations were found in the genetic materials evaluated.

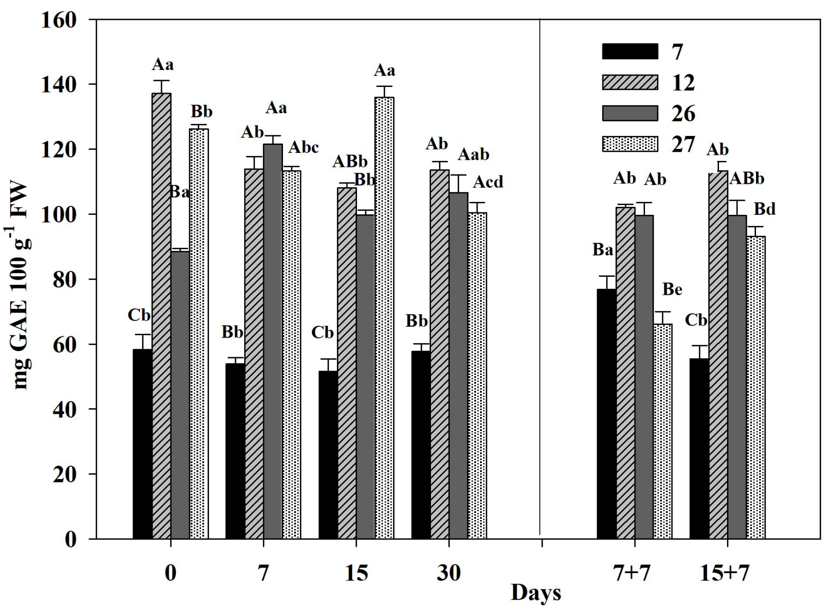

Figure 6 - Total polyphenols contents of feijoa fruit stored at 5°C for 30 days followed by 7 days at 20 °C. Vertical bars represent standard error of the means (n = 3). Means followed by different letters, uppercase for GM in each moment and lowercase for storage time in each GM, are statistically different according to Tukey test at p ≤ 0.05.

Total antioxidant capacity

The TAC values displayed a behavior similar to that of the TPC. GM7 showed the lowest content with around 100 mg AAE 100 g^{-1} FW, almost half of the content measured in the remaining materials with values between 150 and 250 mg AAE 100 g^{-1} FW. The highest values corresponded to GM12 and GM27 (Figure 7). Concerning the evolution over time, generally, a reduction was found with the course of refrigerated storage, but not in the corresponding shelf-life period.

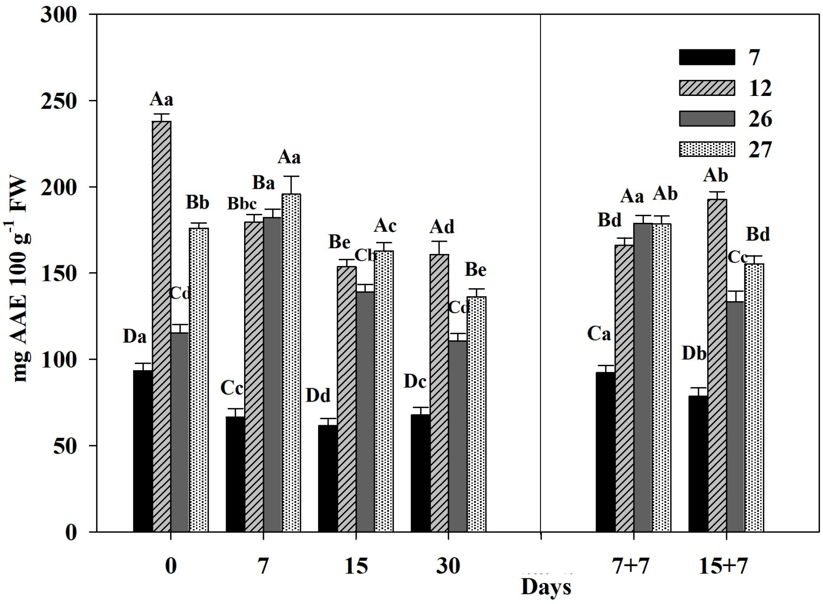

Figure 7 - Total antioxidant capacity of feijoa fruit stored at 5°C for 30 days followed by 7 days at 20 °C. Vertical bars represent standard error of the means (n = 3). Means followed by different letters, uppercase for GM in each moment and lowercase for storage time in each GM, are statistically different according to Tukey test at $p \leq 0.05$.

Other authors have also reported similar behaviors between the TPC and the TAC where the differences between genotypes are maintained (PASQUARIELLO et al., 2015; AMARANTE et al., 2017b). The similarities with the TPC are that these compounds are components of TAC of the fruits. In this case, a positive correlation was found between them ($r = 0.61$ $p < 0.0001$). Phan et al. (2019) affirmed that the TAC occurred by the synergistic function of polyphenols, flavonoids, and ascorbic acid and reported a positive correlation of $r = 0.91$, $r = 0.83$, and $r = 0.825$, respectively ($p < 0.01$).

Conclusion

The GM 26 and 27 softened the most. Also, GM 26 lost more weight. However, GM 27 and 12 stood out in terms of functional compounds. Although GM 7 presented almost half of the content of these compounds, it showed a better internal quality due to less browning. Despite having a higher respiratory activity, GM 12 turned out to be one of the most promising.

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