

Postharvest conservation of strawberries from three new accessions cultivated in the south of Minas Gerais – Brazil

Conservação pós-colheita de morangos de três novos acessos cultivados no sul de Minas Gerais – Brasil

Conservación poscosecha de fresas de tres nuevas accesiones cultivadas en el sur de Minas Gerais – Brasil

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Natali Ribeiro

ORCID: <https://orcid.org/0000-0003-0450-8453>
Universidade Federal Rural do Rio de Janeiro, Brasil
E-mail: natali.ribeiro22@gmail.com

Luiz Fernando de Sousa Antunes

ORCID: <https://orcid.org/0000-0001-8315-4213>
Universidade Federal Rural do Rio de Janeiro, Brasil
E-mail: fernando.ufrrj.agro@gmail.com.br

Adamastor Pereira Barros

ORCID: <https://orcid.org/0000-0002-6796-8281>
Universidade Federal Rural do Rio de Janeiro, Brasil
E-mail: adamastor007@gmail.com

Regina Celi Cavestré Coneglian

ORCID: <https://orcid.org/0000-0002-0663-1028>
Universidade Federal Rural do Rio de Janeiro, Brasil
E-mail: carlosantonioids@hotmail.com

Margarida Goréte Ferreira do Carmo

ORCID: <https://orcid.org/0000-0002-0955-091X>
Universidade Federal Rural do Rio de Janeiro, Brasil
E-mail: gorete.carmo1@gmail.com

Abstract

The objective of this work was to evaluate the postharvest conservation of fruits of three strawberry accessions (NP4, NP9, NP15) under two storage conditions, comparing them with the fruits of cv. Oso Grande (control treatment). The fruits, with 75% of their surface with red color, were harvested, selected and placed in PET containers with lid and stored under ambient conditions (20 ± 3 °C and $81\pm 7\%$ relative humidity) and under refrigeration (5 ± 1 °C and $90\pm 4\%$ relative humidity). During the 11 days of storage, the following evaluations were carried out: total soluble solids (TSS), total titratable acidity (TTA), TSS/TTA ratio, pH and the loss of mass of fruits kept under different storage conditions. Under environmental conditions, the maximum longevity of the fruits was three days and the best preservation was observed in the fruits of the NP9 strawberry tree. Under refrigeration, the longevity of the fruits extended until the 11th day, when the fruits of the NP9 and NP15 access strawberries exhibited better characteristics when compared to the fruits of NP4 and 'Oso Grande', thus representing a new option for growing fruits for consumption *in natura* for producers in southern Minas Gerais.

Keywords: *Fragaria x ananassa* Duch.; Physicochemical quality; Post-harvest conservation; Lifespan; Consumer market.

Resumo

O objetivo deste trabalho foi avaliar a conservação pós-colheita de frutos de três acessos de morangueiro (NP4, NP9, NP15) em duas condições de armazenamento, comparando-os com os frutos da cv. Oso Grande (tratamento controle). Os frutos, com 75% de sua superfície com coloração vermelha, foram colhidos, selecionados e acondicionados em embalagens pet com tampa e armazenados em condições ambiente (20 ± 3 °C e $81\pm 7\%$ de umidade relativa) e sob refrigeração (5 ± 1 °C e $90\pm 4\%$ de umidade relativa). Durante os 11 dias de armazenamento, foram realizadas as seguintes avaliações: teores de sólidos solúveis totais (SST), acidez total titulável (ATT), relação SST/ATT, pH e a perda de massa dos frutos mantidos nas diferentes condições de armazenamento. Sob condição ambiente, a longevidade máxima dos frutos foi de três dias e a melhor preservação foi observada nos frutos do morangueiro de acesso NP9. Sob refrigeração, a longevidade dos frutos se estendeu até o 11º dia, onde os frutos dos morangueiros de acesso NP9 e NP15 exibiram melhores características quando comparados aos frutos de NP4 e 'Oso Grande',

representando assim uma nova opção de cultivo de frutos para consumo *in natura* para os produtores do sul de Minas Gerais.

Palavras-chave: *Fragaria x ananassa* Duch.; Qualidade físico-química; Conservação pós-colheita; Vida útil; Mercado consumidor.

Resumen

El objetivo de este trabajo fue evaluar la conservación poscosecha de frutos de tres accesiones de fresa (NP4, NP9, NP15) bajo dos condiciones de almacenamiento, comparándolas con los frutos del cv. Oso Grande (tratamiento testigo). Los frutos, con 75% de su superficie de color rojo, fueron cosechados, seleccionados y empacados en envases de PET con tapa y almacenados en condiciones ambientales (20 ± 3 °C y $81\pm 7\%$ de humedad relativa) y en refrigeración (5 ± 1 °C y $90\pm 4\%$ de humedad relativa). Durante los 11 días de almacenamiento se realizaron las siguientes evaluaciones: sólidos solubles totales (SST), acidez titulable total (TTA), relación SST/ATT, pH y pérdida de peso de frutos mantenidos en diferentes condiciones de almacenamiento. En condiciones ambientales, la máxima longevidad de los frutos fue de tres días y la mejor conservación se observó en los frutos de la accesión de fresa NP9. Bajo refrigeración, la longevidad de los frutos se prolongó hasta el día 11, donde los frutos de fresa accesión NP9 y NP15 exhibieron mejores características al compararlos con los frutos de NP4 y 'Oso Grande', representando así una nueva opción de cultivo de frutos para consumo *in natura* para productores del sur de Minas Gerais.

Palabras clave: *Fragaria x ananassa* Duch.; Calidad físico-química; Conservación poscosecha; Vida útil; Mercado consumidor.

1. Introduction

Strawberry (*Fragaria x ananassa* Duch.) is a pseudo-fruit consisting of a hypertrophied floral receptacle where the true fruits, the achenes, are inserted. It has a high commercial value due to its great demand and consumption versatility, in which about 50% is consumed fresh and 50% is industrialized (Veiga Júnior, 2006), standing out for its organoleptic characteristics, beauty and nutritional and nutraceutical value.

The fruits are sweet, fleshy, succulent, aromatic, red in color, with regular and uniform size and contours, rich in vitamin C, mineral salts (iron, potassium and calcium), phenolic compounds and in antioxidant and anti-inflammatory, anti-carcinogenic substances and anti-neurodegenerative (Rocha et al., 2008; Pineli, 2009; Ronque, 2010). In industry, other products are used for the production of jellies, yogurts, liqueurs and juices (Duarte Filho et al., 2007; Quinato et al., 2007).

The domestic market for strawberries for fresh consumption is hampered by the climatic requirements of the species, high perishability of the fruits, distance and location of the large consumer market. This high fruit perishability results from the rapid loss of water through its epidermis due to its high respiratory rate and large exposed surface in relation to its weight, which causes the fruit to wrinkle and rapid senescence (Cantillano, 2006; Mirahmadi et al., 2011). Furthermore, losses can be aggravated by its high susceptibility to post-harvest diseases caused by various phytopathogens such as *Botrytis cinerea*, *Rhizopus stolonifer*, *Geotrichum candidum*, *Pilidium concavum*, *Pestalotia longisetula*, *Colletotrichum* spp., *Aspergillus niger*, *Cylindros* sp. candelabrum, *Mucor* sp., *Phoma* sp., *Sclerotinia sclerotiorum*, *Cladosporium* sp., and *Penicillium* sp. (Lopes, 2011).

In addition to the intrinsic characteristics of the fruits, longevity and post-harvest quality are directly related to care in the selection and handling, to the ripening point of harvest and to transport and storage conditions. Fruits with fungal infections, improperly handled or advanced ripening can reach the market completely deteriorated. On the other hand, if picked immature, they will have high acidity, astringency and absence of aroma. In addition, it is not common to adopt appropriate practices for better conservation of fruits, from harvesting, transport and in commercial places, whether in the management of the environment or in the handling of fruits and packaging (Cantillano, 2006).

To minimize physiological and pathological losses in the post-harvest phase, refrigeration is one of the most important practices. Transport and storage at low temperatures contribute to minimizing physical and chemical changes, in addition to losses caused by post-harvest pathogens (Chitarra & Chitarra, 2005; Cantillano et al., 2008). The choice of cultivars with good agronomic and commercial characteristics and good adaptation to edaphoclimatic conditions to the places and growing seasons

is also essential to obtain longer and better fruit longevity (Oliveira & Antunes, 2016).

The storage period and conditions and the characteristics of the fruits of each strawberry cultivar directly influence their postharvest longevity. In a cold room (at a temperature of 2.34 ± 0.78 °C), Andrade Júnior *et al.* (2016) observed at nine days of storage an average incidence of 6.7% of infected strawberry fruits in seven evaluated cultivars and 0% in cv. Diamond. Cantillano *et al.* (2008) observed during storage at 0 °C that 'Camino Real' and 'Ventana' strawberry fruits remained in good quality only until the third and sixth day of storage, respectively. In other words, both handling and storage conditions and cultivar characteristics, including greater post-harvest longevity, are essential to the production and marketing chain of strawberries in Brazil.

Given the above, this study aimed to evaluate the characteristics of the fruits of three new strawberry accessions (NP4, NP9 and NP15), developed by a family farmer, regarding longevity and postharvest quality at room temperature, since it is known that producers do not use refrigeration after harvest and also during transport, and refrigerated, comparing them to the fruits of one of the most planted cultivars in Brazil, 'Oso Grande'.

2. Material and Methods

Strawberries were harvested in an experiment conducted at Sítio Dois Irmãos, municipality of Estiva (MG), Brazil, geographic coordinates $22^{\circ}28'36.3''S$, $46^{\circ}03'31''W$ and Cwb climate, humid temperate with a dry winter and summer tempered according to Köppen-Geiger classification, under conventional production system, in soil, with low tunnel and drip irrigation system.

The treatments consisted of accessions NP4 (cross between 'Oso Grande' and 'IAC Campinas'), NP9 (cross between NP4 and 'Tudla') and NP15 (cross between NP9 and 'San Andreas'), which were designed on the property family farmer Pedro Donato Ribeiro and the commercial cultivar Oso Grande (held as control), which is registered in the National Cultivar Registry of the Ministry of Agriculture, Livestock and Supply, considered one of the most cultivated in Brazil. Cultivar Oso Grande, was developed at the University of California – USA in 1987, has very vigorous plants, its fruits are tasty, bright red and lighter husk and have a short-day photoperiod (they are induced to flowering when the photoperiod is shorter than than 12 hours and low ambient temperature). The cultivar Milsei-Tudla, developed by Planasa in Spain in 1996, has a globose size, large fruits with a homogeneous red pulp, but is susceptible to phytopathogenic fungi that inhabit the soil and has a short-day photoperiod. 'San Andreas', developed by the University of California – USA in 2009, has high vigor, exceptional appearance fruits and good resistance to diseases and neutral day photoperiod (regardless of the length of day to start flowering). 'IAC Campinas' was developed by the Instituto Agrônômico de Campinas, Brazilian agency, in 1960. It is a vigorous plant, red-pink fruits, short day photoperiod (Costa *et al.*, 2014).

The seedlings were transplanted on April 12, and the fruit was harvested on August 19, 2019. Soon after harvesting, the fruits were selected according to their degree of maturity, 75% of their surface being red, and packed in packages pet with 15µ lid and dimensions of 165 x 95 x 30 mm. No treatment was applied to pre and post-harvest fruits, simulating the routine reality of a strawberry producer. Soon after, the pet packages were transported under refrigeration, air conditioning (20 °C), for 5 hours of travel, to the premises of the Post-harvest Laboratory of the Department of Plant Science of the Federal Rural University of Rio de Janeiro (UFRRJ), Seropédica – RJ, where they were stored under two conditions: ambient (20 ± 3 °C and $81\% \pm 7\%$ relative humidity) and refrigerator (5 ± 1 °C and $90 \pm 4\%$ relative humidity), as two distinct experiments. In both experiments, a randomized block design (DBC) in a 4 x 6 factorial scheme was adopted, consisting of four genotypes (NP4, NP9, NP15 and 'Oso Grande') and six storage periods (1, 3, 5, 7, 9 and 11 days), with five repetitions. Each repetition consisted of a pet package containing approximately 215 g of strawberry fruits.

The characteristics evaluated were: total titratable acidity (TTA), total soluble solids (TSS), relationship between TSS and TTA, hydrogen potential (pH) and loss of fresh mass. a) TTA determined by titration of 5.0g of macerated fruits diluted in 30 ml of distilled water under moderate agitation. Titration was performed with a standardized 0.1M sodium hydroxide (NaOH) solution using 1% phenolphthalein pH 8.0 as an indicator. The result was expressed in % citric acid (IAL, 2008); b) TSS content determined in direct reading in the fruit juice (20g macerated) using a manual refractometer, with results expressed in °Brix (IAL, 2008); c) Relation between TSS and TTA determined by calculating the ratio between these two components; d) pH determined directly in the fruit juice (20g macerated) using the Akso® portable pHmeter, model AK90, and e) Loss of fresh mass determined by weighing every two days to measure the fresh mass followed by calculating the difference with respect to initial mass of pet packages. Weighing was done on a digital scale (Acculab, model V-200) with precision of two decimal places and data expressed in percentage, always carried out in the same pet packages.

As assumptions of the regression analysis, the homogeneity of the variances was tested by the oneillmathews test and the normality of the residuals by the Shapiro-Wilk test, both at 5% significance. The mean TSS/TTA ratio at room temperature and TSS at refrigeration were transformed into $\log(x+0.1)$ and \sqrt{x} , respectively, to meet the assumption of the analysis of variance. Then, analysis of variance was performed to test the simple effect and the interaction between genotype and storage time. To compare the means of the genotypes, the Tukey test was used ($p < 0.05$) and for the effect of storage time, linear regression analysis ($\bar{y} = \alpha + \beta x$) was applied. The statistical package used was ExpDes.pt in the R environment. version 3.6.6.

3. Results

Experiment 1 - storage at ambient temperature conditions (20 ± 3 °C and $81 \pm 7\%$ relative humidity)

The fruits were intact only until the fourth day after harvest. Thus, evaluations were carried out only on two dates, with one and three days of storage. In the five-day evaluation, a high percentage of fruits infected by the fungi *Botrytis cinerea*, *Rhizopus stolonifer* and *Colletotrichum* spp. in the four genotypes, which made them unviable for commercialization.

As there was no significant effect of the interaction between genotype and storage time on any of the variables evaluated, the effect of each factor was analyzed separately (Table 1). The storage time only affected the pH values of the fruits, which were higher at three days when compared to the first day. However, there were significant differences between the genotypes in terms of TSS and pH levels and no difference for the variables TTA, TSS/TTA and mass loss. The highest TSS content was observed in accession NP9 (5.61 °Brix) followed by NP15 (5.45 °Brix) and Oso Grande (5.17 °Brix), which did not differ from each other. The fruits of accession NP4 had significantly lower °Brix (4.65 °Brix). The fruits of the NP9 accession were also the ones with higher pH values (3.65) and those of NP15, the lowest (3.40) (Table 1). Regarding fresh mass losses, these were similar among the four genotypes, ranging from 1.07% in NP15 to 1.89% in NP4. (Table 1).

Table 1. Mean values of total soluble solids (TSS), total titratable acidity (TTA), relationship between TSS/TTA, pH and weight loss in fruits of four strawberry genotypes conditioned at room temperature (20 ± 3 °C and $81 \pm 7\%$ relative humidity), evaluated after one and three days after harvest.

Factors	TSS(°Brix)	TTA (%)	TSS/TTA	pH	Weight loss (%)*	
Time (days)	1	5.31 a	0.49a	11.53a	3.45b	-
	3	5.13 a	0.45a	11.56a	3.65a	-
Genotype	NP15	5.45 ab	0.48a	11.66a	3.40 b	1.07 a
	NP9	5.61 a	0.49a	12.08a	3.65 a	1.35 a
	NP4	4.65 b	0.46a	10.29a	3.58 ab	1.89 a
	Oso Grande	5.17 ab	0.46a	12.14a	3.58 ab	1.38 a
CV (%)	13.82	21.06	10.86	4.69	31.80	

Means of the same factor followed by the same letter in the column do not differ statistically from each other by the Tukey test ($p < 0.05$). *Percentage loss of mass after three days of storage. Source: Authors.

Experiment 2 - refrigerated storage (5 ± 1 °C and $90 \pm 4\%$ relative humidity)

The fruits of accession NP15 and NP9 remained with good characteristics and suitable for commercialization until the 11th day and those of the NP4 and 'Oso Grande' strawberries until the nine days, an important fact in terms of postharvest evaluation of the genotypes. The deterioration of fruits from NP4 and 'Oso Grande' strawberries was accelerated by the higher incidence of the aforementioned fungi and greater loss of fresh mass, making them with a wilted appearance. The results of these two experiments confirm the importance of refrigeration in the postharvest conservation of strawberries in tropical conditions in Brazil, as described by Cantillano (2003), keeping them marketable for longer and consequently reducing waste.

Only simple effect of genotype and storage time on TSS contents was observed. The TSS contents varied with the storage time, showing the highest value on the third day (5.88 °Brix) and the lowest value on the fifth day (4.76 °Brix). Similar to what was observed in the test under storage conditions at room temperature, the fruits of the NP9 genotype were the ones with the highest levels of TSS (5.81 °Brix), followed by NP15 (5.39 °Brix) and 'Oso Grande' (5.24 °Brix), which did not differ statistically from each other, and the lowest values in NP4 (4.92 °Brix), differing only from NP9 (Table 2).

Table 2. Total soluble solids (°Brix) of fruits of four strawberry genotypes submitted to different storage periods under refrigeration (5 ± 1 °C and $90 \pm 4\%$ of relative humidity).

Factors	TSS (°Brix)	
Time (days) ¹	1	5.26 ab
	3	5.88 a
	5	4.76 b
	7	5.31 ab
	9	5.60 ab
	11	5.38 ab
Genotype ²	NP15	5.39 ab
	NP9	5.81 a
	NP4	4.92 b
	Oso Grande	5.24 ab
CV % = 7.92		

Means of the same factor followed by the same letter do not differ statistically from each other by the Tukey test ($p < 0.05$).¹ At time 11, only the mean of accessions NP9 and NP15. ² For the NP4 and 'Oso Grande' genotypes, the averages were considered until the 9th evaluation and for NP9 and NP15, the average was considered until the 11th evaluation. Source: Authors.

Unlike the experiment that evaluated strawberries under room temperature conditions, where no effect of time or genotype on TTA was recorded, in the refrigerated experiment there was a significant effect of genotype x storage time interaction. The absence of effect in the first trial is probably due to its short duration of only three days, whose TTA means

ranged from 0.46% in 'Oso Grande' to 0.49% in NP9 (Table 1), higher than those recorded for strawberries stored under refrigeration, whose mean values were 0.33% in the NP15 genotype and 0.40% in NP9 for the same three-day period (Figure 1-A).

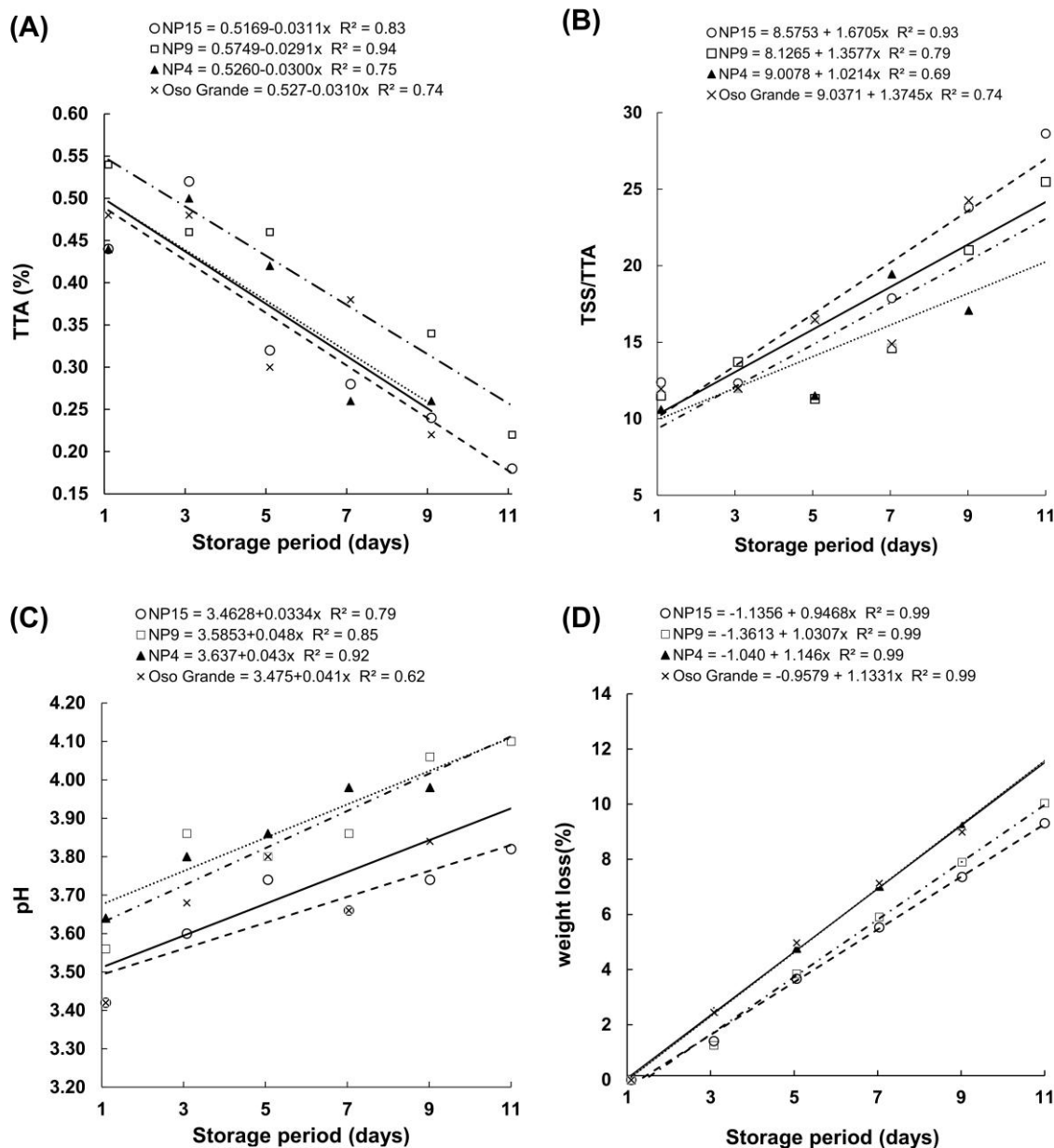
In the second experiment, there was a significant linear reduction in the TTA of the fruits of the four strawberry genotypes over the 11 days, however, significant differences were only observed between the genotypes at seven and nine days of storage, with higher values for the Oso Grande genotype (0.38% and 0.22%), NP9 (0.38% and 0.34%) and smaller in NP15 (0.28% and 0.24%) and NP4 (0.26% and 0.26 %), respectively (Figure 1A). In general, the lowest TTA was recorded in the fruits of the NP15 genotype (0.44% to 0.18%) compared to the means of the other genotypes.

The same significant effect was observed for the TSS/TTA ratio only in the refrigerated storage experiment, in which there was a significant effect of the genotype x storage time interaction with a significant linear increase in the TSS/TTA ratio as a function of the fruit storage time for the four genotypes. However, there were no significant differences between the fruits of the four genotypes on any of the evaluated dates (Figure 1B) and the mean TSS/TTA values ranged from 14.11 (NP4 genotype) to 18.6 (NP15 genotype). The increase in the TSS/TTA ratio is due to the little variation in TSS values and the progressive decrease in TTA values (Table 2 and Figure 1A). The fruits of the NP15 accession were the ones with the highest β value, which probably implies a slower loss of quality over time when compared to the fruits of the other genotypes (Figure 1B).

Unlike the pH values of the first experiment, where there was a simple effect of genotype and time on the pH of the fruits, in the second there was a significant effect of the genotype x storage time under refrigeration interaction, with increased pH values as required. in which storage time was advanced with significant differences between the genotypes at 7, 9 and 11 days (Figure 1C). Higher pH values were identified in the fruits of genotypes NP4 (3.98 and 3.98) and NP9 (3.86 and 4.10) compared to genotypes NP15 (3.66 and 3.74) and 'Oso Grande' (3.66 and 3.84) at seven and nine days, respectively (Figure 1C). The fruits of accessions NP9 and NP15 showed a significant difference between them, with NP9 showing the highest pH value (4.10) and NP15 the lowest value (3.82).

As for the loss of fruit mass, there were linear and significant increases for the four genotypes (Figure 1D). At nine days, the loss of fruit mass ranged from 7.4 to 9.2% in NP15 and NP4, respectively. Although no significant differences were observed between the genotypes, the loss of mass was slower in the fruits of accessions NP15 and NP9, identified by the lower slope values of the straight lines (Figure 1D), in addition to having a longer shelf life (11 days) in relation to genotype NP4 and 'Oso Grande' (9 days).

Figure 1. Variation of total titrable acidity (TTA) (A), ratio between total soluble solids (TSS) and total titrable acidity (TTA) (TSS/TTA) (B), pH (C) and weight loss (D) of four genotypes from strawberry during 11 days of refrigeration storage (5 ± 1 °C and $90 \pm 4\%$ relative humidity).



In each graph, means of genotypes followed by the same letter do not differ statistically from each other, in the respective evaluation dates, by the Tukey test ($p < 0.05$). Followed by “*” differ by the F test ($p < 0.05$). Source: Authors.

4. Discussion

Differences between genotypes and edaphoclimatic conditions can cause variations in the levels of TSS, according to Goto (1998). The TSS contents, an indicator of the amount of sugars present in the fruit (Portela et al., 2012), in the two tests, are compatible with those described for strawberry, ranging from 4.2 to 10.3 °Brix (Correia et al., 2011; Andrade Júnior et al., 2016). The reduction in TSS contents over time, observed in both the first and second experiments, from the first to the last evaluation, was possibly due to the consumption of energy in fruit respiration and thus there was the mobilization of part of the soluble solids (Pelayo-Zaldívar et al., 2005). The differences in TSS contents observed in the fruits of the four genotypes

observed in this study are common in strawberry and in fruits of other species, being an important feature in the selection of cultivars, as this behavior directly affects the quality and flavor of the fruits (Goto, 1998; Conti et al., 2002; Portela et al., 2012).

Andrade Júnior et al. (2016), aiming to evaluate the postharvest conservation of fruits of eight strawberry cultivars under different storage conditions, also found oscillations in the values of °Brix of strawberries during the 12 days of cold storage, ranging from 5.8 in the time 0, 6.1 at time 3, 5.7 at time 6, 5.6 at time 9 and 5.1 at time 12. These results corroborate those found in the present study.

The reduction in TTA is normally associated with the high activity of the enzyme ascorbic acid oxidase involved in the degradation of acids during the respiratory process (Brackmann et al., 2011). The evaluation of TTA is a very important variable in the characterization of the fruits as it provides valuable data regarding their conservation status (IAL, 1985) and it can vary between 0.6 and 2.3%, with strawberries that have lower acidity. more pleasant and tasty (Cordenunsi et al., 2002). According to Kader (1999), the maximum acceptable TTA in strawberries, corresponding to a pleasant taste, is 0.8%. Thus, all cultivars are within the recommended TTA (Table 1). The mean values of TTA found in strawberry vary from 0.24 to 0.99 according to the cultivar and its conservation status (Costa et al., 2010; Correia et al., 2011; Ávila et al., 2012). Andrade Júnior et al. (2016) observed in three different strawberry cultivars, Campinas, Oso Grande and Camarosa, TTA values equal to 0.4, 0.6 and 0.7% respectively, after 12 days of storage at a temperature of 2.34 ± 0.78 °C and relative humidity of $89.93 \pm 4.14\%$. In turn, Brackmann (2011) recorded TTA values ranging from 0.52 to 0.70% in fruits of two strawberry clones, LBG 121.4 and LBK 28.1, respectively, stored for 10 days at -0.5 °C followed by two days at 20°C. It is noted that in both studies, the TTA values are higher than those found in the present study.

The reduction in the TSS/TTA ratio indicates loss of fruit quality and when it reaches very low values, it indicates that they are tasteless (Aked, 2002), contrary to what was observed in this work until the 11th day. The TSS/TTA values in the two experiments are compatible with the values described in the literature for strawberry, which is from 5.38 to 13.44 (Brackmann et al., 2011; Ávila et al., 2012). These values may also vary with genotype, time and storage conditions. Andrade Júnior et al. (2016), when evaluating fruits of three strawberry cultivars stored for 12 at a temperature of 2.34 ± 0.78 °C and relative humidity of $89.93\% \pm 4.14\%$, recorded mean values of TSS/TTA of 7.8, 10.5 and 12.3 in fruits of 'Dover', 'Oso Grande' and 'Campinas' genotypes, respectively, which were lower than those observed in this work.: The same was observed by Brackmann *et al.* (2011), working with strawberry fruits stored for 10 days at -0.5 °C followed by two days at 20 °C, where TSS/TTA values ranged from 8.93 to 13.44.

Normally, fruits with pH values lower than 3.5 are more appropriate for the industry and fruits with a pH higher than 3.5 are more suitable for fresh consumption (Passos, 1982). In general, these pH values are compatible with those described for strawberry fruits, from 3.23 to 3.84 (Conti et al., 2002; Cantillano et al., 2008).

Another important indicator of fruit quality during storage is the loss of mass, which is due to the loss of water through transpiration and the metabolic processes of fruit respiration (Antunes et al., 2003). With the loss of mass, changes in fruit texture also occur due to the partial hydrolysis of insoluble protopectin and formation of soluble pectin, resulting in loss of firmness and fruit quality (Cantillano et al., 2008). The loss of mass recorded in this work is below that mentioned by Hernández-Muñoz *et al.* (2006) as harmful to fruit quality (10%) and equivalent to that reported by Ávila *et al.* (2012) in a cold room trial at 1 ± 0.5 °C and 90-95% relative humidity with values of 8.93% and 9.49% in the cultivars Camino Real and Camarosa, respectively. Guimaraes *et al.* (2017), at the end of 12 days of refrigerated storage, they found losses ranging from 0.85 to 2.13%, which can be explained by the use of a Styrofoam tray and 15µ PVC film, which reduced the loss of water, providing longer shelf life.

The differences observed in this research in relation to the studied variables are related both to the genotype and its

mechanical resistance to handling, as well as to the use of packaging and transport, as well as the conditions of the storage environment, especially temperature and relative humidity, and their effects on the rate of respiratory (Chitarra & Chitarra, 2005). Both factors directly affect membrane integrity and loss of cellular content and, consequently, the intensity of damage to fruits identifiable by symptoms such as wilting, loss of succulence and postharvest shelf life (Brackmann et al., 2011).

Therefore, these three new strawberry accessions showed good post-harvest potential, since they are equivalent to and/or superior to one of the most planted cultivars in the country, requiring further studies on the agronomic characterization to be marketed in Brazil, once which are national accesses, which would reduce production costs for farmers.

5. Conclusions

The fruits of the NP9 and NP15 genotypes show good post-harvest conservation under refrigeration, which can be sold in tray-type packaging with a lid with up to 11 days of storage at a temperature of $5 \pm 1^\circ\text{C}$ and relative humidity of $90 \pm 4\%$.

Thus, NP9 and NP15 access strawberries can be recommended to strawberry producers in the region of Estiva-MG, in addition to other producing regions, in order to serve the consumer market with fresh fruit.

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