REFERÊNCIA

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'SWEET GRAPE' TOMATO POST HARVEST PACKAGING

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ABSTRACT: This paper aims at evaluating the shelf life of mini tomatoes (*Lycopersicum esculentum* Mill.) cultivar 'Sweet Grape', grown in hydroponics, and stored under environmental and refrigerated conditions inside different packages. We adopted a completely randomized design, in which treatments were combinations of storage conditions: environment (e) and refrigerated (r) with packaging: polyvinyl chloride film (PVC); low-density polyethylene (LDPE); biofilm of tomato fruit of *Solanum lycocarpum* A.St.-Hil (*lobeira*) (TFB); cassava starch biofilm (CSB); carnauba wax (*Copernicia prunifera*) (CW), and without packaging - control (C). Physicochemical and sensory tests were carried out at the beginning (day zero), and at 8, 19, and 33 days of storage (DS). Fruit stored inside PVCr, LDPEe, LDPEr, and CWr had an acceptable shelf life of 33 days. The use of cassava and tomato starches were not effective in controlling fruit fresh weight loss. 'Sweet Grape' tomato postharvest conservation was enhanced under refrigerated conditions. The sensory evaluation results revealed that CWr treatment most pleased appraisers, while PCV had the highest rejection rate.

KEYWORDS: *Lycopersicon esculentum* Mill.; storage; shelf life; lifespan; expiration; expiry date.

DIFERENTES EMBALAGENS NA CONSERVAÇÃO PÓS-COLHEITA DO MINITOMATE *SWEET GRAPE*

RESUMO: Objetivou-se avaliar a vida útil do minitomate (*Lycopersicum esculentum* Mill.), variedade *Sweet Grape*, produzido em hidroponia e armazenado sob condição ambiente e refrigerada, em diferentes embalagens. Adotou-se o delineamento experimental inteiramente casualizado, em que os tratamentos consistiram na combinação da condição de armazenamento: ambiente (a) e refrigerada (r), e tipo de embalagem: filme flexível de policloreto de vinila (PVC); polietileno de baixa densidade (PEBD); biofilme de fruto de *Solanum lycocarpum* A.St.-Hil (lobeira) (BFL); biofilme de fécula de mandioca (BFM); cera de *Copernicia prunifera* (carnaúba) (CC), e sem embalagem - testemunha (T). As análises físico-químicas e sensoriais foram realizadas no início (dia zero), aos 8, 19 e 33 dias de armazenamento (DA). Os frutos submetidos às embalagens PVCr, PEBDa, PEBDr e CCr apresentam vida útil aceitável de 33 dias de armazenamento. A aplicação de biofilmes de amidos de fruto de lobeira e mandioca não é eficaz no controle da perda de massa fresca. A condição refrigerada é a melhor forma para a conservação pós-colheita dos frutos de minitomate. O tratamento CCr é o que mais agrada os julgadores, e o PCV, o de maior índice de rejeição.

PALAVRAS-CHAVE: *Lycopersicon esculentum* Mill., estocagem, vida útil, ciclo de vida , validade, tempo de expiração.

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INTRODUCTION

The cultivar 'Sweet Grape' belongs to the group of mini tomatoes and has distinctive size and taste, which is recommended to be harvested at a minimum Brix degree of 6.0 and with an average fresh weight of 12 g per fruit. The Brazilian production is estimated at 1,700 tons and the latest estimates predict a total of 89,000 tons in 2013 (JUNQUEIRA, 2011). This vegetable is very attractive and has high added value, encouraging farmers to invest in modern technologies that would raise productivity (ABRAHÃO et al., 2011a; ABRAHÃO et al., 2011b). The crop has been grown in greenhouses using a flow-through hydroponic system. In this model, plants are cultivated in pots or bags without ground contact, providing an enhanced control of nutrition and diseases (RIBEIRO, 2011), mainly at locations within the Midwest and Southeastern Brazil, where production cycle ranges from 6 to 8 months and yield rates varies between 6 and 10 kg plant^{-1} cycle^{-1}.

Cultivation, handling, and postharvest technologies interfere decisively with fruit shelf life term, since these products undergo important metabolic changes, which may depreciate final product commercially by compromising fruit appearance, aroma, and flavor, as well as the possibility nutritional compound losses. Thus, temperature control coupled with judicious use of appropriate packaging and atmosphere modification are effective in controlling the metabolic processes. According to RINALDI et al. (2011), a potentially viable alternative for fruit and vegetable preservation is the usage of refrigeration for storage; this method reduces temperature and relative humidity, delaying deterioration by decreasing the cellular metabolism. FERREIRA et al. (2010) reported that besides influencing postharvest ripening and postharvest life, tomato ripeness degree plays a significant role in consumer choice, along with the size, shape, and external defects, which may change due to production and storage factors.

Fruit and vegetable packaging can be made of plastic films that reduce transpiration and modify the surrounding atmosphere, serving as protection against surface abrasion. Edible films have been used as an alternative to synthetic and non-degradable packages to reduce fruit respiration, to delay moisture loss and color variation, and to improve softening and mechanical integrity, retaining aroma and inhibiting microorganism growth (GARCIA et al., 2010). Starch is an interesting alternative as biodegradable polymer, due to its economic importance, besides deriving from renewable and environmental sources as well as being biodegradable (MALI et al., 2010).

Plastics made exclusively of starch are hardly suitable to conventional procedures of packaging manufacture; therefore, introducing additives to polymeric matrices, known as plasticizers such as glycerol and sorbitol, is needed (SANTOS, 2009; MALI et al., 2010). Thus, it is desirable that these films and edible coatings exhibit neutral sensory properties such as being transparent, odorless, and insipid (PRATES & ASCHERI, 2011).

The use of modified atmosphere and fruit packaging with cassava starch have been widely used (SANTOS et al., 2011), since both techniques are inexpensive compared to commercial waxes. Another interesting alternative is to pack fruit with starch from tomato fruit of the species *Solanum lycocarpum* A.St.Hil (*lobeira*). This fruit became a good alternative because is available in nature, not used in human nutrition, and contains high levels of starch and amylose (PRATES & ASCHERI, 2011). Likewise, carnauba wax has been widely applied as conservative in tomato postharvest both in Brazil and in other countries (ASSIS et al., 2008).

This way, this paper has the aim of assessing postharvest lifespan of mini tomatoes cultivar 'Sweet Grape', produced hydroponically, and stored inside different packages under environmental and refrigerated conditions.

MATERIAL AND METHODS

Seedlings of mini tomatoes, cultivar 'Sweet Grape', were grown in hydroponic system under greenhouses located at the Academic Unit of Exact and Technological Sciences, which belongs to the State University of Goiás (UnUCET/ UEG), in Anápolis – GO, Brazil. The seedlings were fertilized with treated sewage wastewater coming from the ETE/ UnUCET/ UEG sewage treatment plant. Prior to application, the effluent was enriched with commercial nutrients and applied by drip irrigation into 8-L pots filled with natural coconut fiber.

After being harvested at ripeness point, which is when skin become deep red and uniform. As recommendations of the Sakata Company, the fruits were mixed and randomly selected into thirty-fruit groups, one for each postharvest treatment.

Postharvest evaluations were carried at Embrapa Cerrados, in Planaltina – DF, Brazil, from August to October of 2011. Storage and all analyzes were performed at the Laboratory of Science, Food Technology and Postharvest.

As soon fruit were left in the laboratory, they were sorted according to apparent external defects and disease occurrence. Then, fresh weight measurements were carried using an analytical scale, with precision of 0.001 g. Soon after, physical characteristics, such as diameter, height, internal cavity size, and pulp thickness were recorded with a digital caliper with precision of 0.1 mm. Fruit shape index was calculated by the ratio between height and diameter. Finally, fruit were randomly divided into thirty groups and subjected to different treatments.

The treatments consisted of cross comparisons between storage conditions and used packages. Fruit were stored both at room condition (e) as refrigerated (r). We wrapped the fruit with biofilm made of *Solanum lycocarpum* (*lobeira*) starch (TFB) (2%); cassava starch biofilm (CSB) (3%); 30-mm flexible polyvinyl chloride film (PVC), which were on expanded polystyrene trays with dimensions of 22 cm x 17 cm x 3 cm; 50-mm low density polyethylene bags (LDPE) with dimensions of 20 cm x 30 cm; coating of carnauba wax (extracted from *Copernicia prunifera* palms) at a concentration of 18%; and control samples without any packaging.

The treatments were evaluated in a completely randomized design with three replicates per treatment, with each repetition consisted of thirty fruits of mini tomato. The results were submitted to mean comparison by the Tukey test at 5% probability, using the ESTAT software (1994). The types of packages were compared at each storage day and storage days for each packaging type, separately.

Carnauba wax (Aruá tropical Br-A2) was applied on fruit by hand with the aid of a disposable glove, for enhanced spreading, using 1 L wax per each ton of fruit. For starch biofilm of tomato fruit, we prepared a solution of starch (2%, i.e. 2 g per 100 mL) and sorbitol (40%, i.e. 0.8 g per 100 mL). This solution was heated up to 95 °C, for 5 min; when room temperature was reached, fruit were immersed into this solution for 5 min (SANTOS, 2009). Cassava starch biofilm was obtained through a starch solution (3%, i.e. 60 g in 2 L), as proposed by SANTOS et al. (2011).

Starch suspension in water was heated up to 70 ºC, under constant stirring, until gel setting. Subsequently, the suspension was left cooling down at room temperature for further fruit soaking during 3 min. Then, fruit were placed on sieves for biofilm draining and drying.

Fruit stored at room temperature were left on lab benches, where the average temperature and relative humidity were respectively 24 °C and 34.7%, during the 33-day experiment. As for the fruits stored under refrigerated condition, the temperature was around 12 °C ± 1 ° C and relative humidity of 90%.

Determinations of pH, soluble solids (SS), titratable acidity (TA), SS/ TA ratio, pulp firmness, ascorbic acid, weight loss, moisture, total solids of fruit were performed at the beginning of the experiment (day zero), and at 8, 19, and 33 days of storage (DS). We also carried a sensory analysis of certain fruit attributes such as overall appearance, color, texture, aroma, and purchase decision at the same days.

The pH was determined by pH meter with a digital bench potentiometer and soluble solids by digital bench refractometer with automatic temperature correction to 20 °C and accuracy of 0.1%. Titratable acidity, ascorbic acid, moisture, total solids, and SS/ TA ratio were obtained according methodology developed by CARVALHO et al. (1990). Pulp firmness was obtained with the aid of an analog manual penetrometer (Instruturn PTR-100) with 0.5 kg scale that is proper for tomato analysis.

Sensory tests were carried using an affective-quantitative method with a 9-point structured hedonic scale, according to FERREIRA (2000). We invited forty non-trained consumers to be appraisers (judges), who gave scores to the fruit regarding each characteristic. The hedonic scale was of nine points, namely: "like extremely", "like very much", "like moderately", "like slightly", "neither like nor dislike", "dislike slightly", "dislike moderately", "dislike very much", and "dislike extremely", which were listed in the descending order from 9 to 1, respectively.

Another judging panel composed by college interns, technicians, and researchers who also gave scores according to their personal degree of satisfaction to each sample. The samples were provided to appraisers randomly, being placed on white plastic dishes coded with random three-digit numbers respective to each sample. Evaluation sheets were given to each of the judges. It was previously established that average scores below 5.0 would be considered unsuitable for product acceptability, i.e. for marketing.

Hence, the lifespan of tomatoes subjected to the treatments in this study followed a minimum standard of acceptability, for each studied variable, being rejected when scores were lower than five; since they are considered undesirable for consumption and consequently dropped out of the analysis. The appraisers also assessed purchase probability, in case this product was available for marketing. In this evaluation, the response alternatives were "certainly buy"; "probably buy"; "may buy / may not buy"; "probably would not buy", and "certainly would not buy".

RESULTS AND DISCUSSION

Results showed an average weight of 16.37 g fruit^{-1}, which is within a range of 10 to 20 g fruit^{-1}; however, this value was higher than that of 9 g fruit^{-1} found by ABRAHÃO et al. (2011b). Fruit average height and diameter were respectively 38.30 mm and 26.26 mm, being within the standards for the cherry group of tomatoes described by the Brazilian Program for Horticulture Modernization, which define equatorial section diameter of cherry tomatoes as smaller than 39 mm. The measurements of internal cavity, pulp thickness, and fruit format index had average values of 17.10 mm, 5.21 mm, and 1.46 mm, respectively.

According to the Table 1, the minimum value of pH at day zero was of 4.06, being lower the values found by ABRAHÃO et al. (2011a) (from 4.13 to 4.20). For all treatments, the highest pH values were observed at the end of lifespan, reaching a maximum of 4.39 at 33 DS for PVCe. Tables 6 and 7 show that significant differences were observed for all treatments between day zero and lifespan end, which was defined by the sensory test. In some cases, such differences were noted only from the eighth DS. Until the 30 DS, all refrigerated treatments had differences from the others, reaching the lowest value (4.18), followed by CWr (4.20), which differed from refrigerated treatments (4.18) and PVCe (4.39). Regarding pH, values less than 4.5 favor conservation for both *in natura* fruit and byproducts (RAUPP et al., 2009).

Table 1 shows that there was a fluctuation of titratable acidity in most treatments. This variable ranged from 0.34% (PVCe and LDPEe) at 33 DS to 0.56% citric acid (Cr and CSBr) at 8 DS. In treatments at day zero, this variation was 0.55% higher than those findings of ABRAHÃO et al. (2011a) (0.43% to 0.48%). According ELOI et al. (2011), high-quality fruit have titratable acidity values greater than 0.32%. Unlike pH, titratable acidity, with some exceptions, was reduced from day zero (raw material) to the 33 DS. Probably, this reduction is a consequence of fruit ability to synthesize organic acids, which are produced with ripening. It is noteworthy mention that intermediate products of fruit respiratory metabolism, as well as organic acids, modify fruit flavor, aroma, color, stability and consequently its quality. Differences between day zero and the end of lifespan were solely found in treatments that achieved 33 DS, and of these, PVCe and LDPEe were significantly lower than the others were.

The lower value of titratable acidity was observed for samples packaged with PVC and LDPE, at 33 DS and the greatest one for CSB under both environmental and refrigerated conditions, after 8 DS.

TABLE 1. Average values of pH and titratable acidity in fruit of ‘Sweet Grape’ mini tomato during storage.

TMT.	Days of storage (DS)				Days of storage (DS)			
	0	8	19	33	0	8	19	33
	pH				Titratable acidity (% citric acid)			
Ce	4.06 Ba	4.15 Aab	-	-	0.55 Aa	0.54 Aab	-	-
Cr	4.06 Ba	4.15 Aab	4.12 ABbc	4.18 Ad	0.55 Aa	0.56 Aa	0.52 ABa	0.47 Ba
PVCe	4.06 Ca	4.12 Cabc	4.26 Ba	4.39 Aa	0.55 Aa	0.49 Bb	0.41 Cb	0.34 Dc
PVCr	4.06 Ca	4.20 Ba	4.06 Cc	4.35Aab	0.55 Aa	0.49 Ab	0.49 Aa	0.40 Bb
LDPEe	4.06 Ca	4.09 Cbc	4.23 Bab	4.36 Aab	0.55 Aa	0.51 Bab	0.42 Cb	0.34 Dc
LDPEr	4.06 Ba	4.07 Bc	4.12 Bbc	4.29 Abc	0.55 Aa	0.50 Bab	0.50 Ba	0.42 Cb
TFBe	4.06 Ba	4.18 Ab	-	-	0.55 Aa	0.54 Aab	-	-
TFBr	4.06 Ba	4.14 Aabc	4.17 Aabc	-	0.55 Aa	0.52 Bab	0.53 ABa	-
CSBe	4.06 Ba	4.17 Aab	-	-	0.55 Aa	0.56 Aa	-	-
CSBr	4.06 Ba	4.18 Aab	4.23 Aab	-	0.55 Aa	0.51 Bab	0.53 ABa	-
CWe	4.06 Ba	4.17 Aab	4.20 Aab	-	0.55 Aa	0.53 Aab	0.53 Aa	-
CWr	4.06 Ba	4.16 Aab	4.18 Aabc	4.20 Acb	0.55 Aa	0.52 Bab	0.54 ABa	0.47 Ca

Control under environmental conditions (Ce) and under refrigerated conditions (Cr); Polyvinyl Chloride flexible film under environmental (PVCe) and refrigerated (PVCr) conditions; Low Density Polyethylene under environmental (LDPEe) and refrigerated (LDPEr) conditions; Tomato Fruit biofilm under environmental (TFBe) and refrigerated (TFBr) conditions; Cassava starch biofilm under environmental (CSBe) and refrigerated (CSBr) conditions; Carnauba wax under environmental (CWe) and refrigerated (CWr) conditions. Treatments (TMT).

Means followed by different uppercase letters within the same line and lowercase within the same column differ from each other at 1% probability by the Tukey test.

- Treatments discarded by sensory tests.

Table 2 shows that ascorbic acid content ranged from 22.94 to 49.73 mg per 100 g fruit pulp from 8 DS to 19 DS, respectively, both for LDPEe. These values are within the acceptable values generally found for tomato (regardless cultivar), which are between 7.20 and 45.60 mg 100 g fruit pulp, depending on the time of year, cultivar, light, fertilizer, substrate, and storage conditions. None of the treatments showed differences between day zero and the end of lifespan. At 19 DS, CSBr and CWe were on expiry date, being shorter than LDPEe that reached 33 DS.

TABLE 2. Average values of ascorbic acid in fruit of ‘Sweet Grape’ mini tomato during storage.

	Days of storage (DS)			
TMT	0	8	19	33
	Ascorbic Acid (mg 100 g pulp^{-1})			
Ce	28.77 Aa	37.23 Aab	-	-
Cr	28.77 Aa	28.58 Aabc	38.45 Aab	29.38 Aa
PVCe	28.77 Aa	26.69 Abc	34.07 Aab	29.18 Aa
PVCr	28.77 Ba	25.34 Bbc	41.01 Aab	31.00 ABa
LDPEe	28.77 Ba	22.94 Bc	49.73 Aa	27.02 Ba
LDPEr	28.77 Ba	26.30 Bbc	46.09 Aab	33.70 ABa
TFBe	28.77 Aa	34.06 Aabc	-	-
TFBr	28.77 Aa	36.80 Aab	33.57 Aab	-
CSBe	28.77 Aa	39.57 Aa	-	-
CSBr	28.77 Aa	34.72 Aabc	31.48 Ab	-
CWe	28.77 Aa	36.48 Aab	32.76 Ab	-
CWr	28.77 Aa	33.64 Aabc	34.00 Aab	27.47 Aa

Control under environmental conditions (Ce) and under refrigerated conditions (Cr); Polyvinyl Chloride flexible film under environmental (PVCe) and refrigerated (PVCr) conditions; Low Density Polyethylene under environmental (LDPEe) and refrigerated (LDPEr) conditions; Tomato Fruit biofilm under environmental (TFBe) and refrigerated (TFBr) conditions; Cassava starch biofilm under environmental (CSBe) and refrigerated (CSBr) conditions; Carnauba wax under environmental (CWe) and refrigerated (CWr) conditions. Treatments (TMT).

Means followed by different uppercase letters within the same line and lowercase within the same column differ from each other at 1% probability by the Tukey test.

- Treatments discarded by sensory tests.

From Table 3, we can observe that CSBe had the lowest average for moisture content (89.50%), but higher for total solids (10.50%) at 8 DS. Therefore, we may conclude that this biofilm was not effective in controlling fruit water loss, statistically differing from day zero. On the other hand, PVCe got the highest humidity (93.11%) and the lowest total solids (6.93%) at 19 DS. Although this treatment did not differ from the others for all evaluation dates, it was the one that stood out, with an average value close to those reported by PINHO et al. (2011) for cherry tomatoes (93% moisture) and ALESSI (2010) for in natura cultivar 'Sweet Grape' frozen and dried by solar and conventional power (90.17%). The amount of total solids in the fruit will determine a higher or lower concentration of soluble components, as well as vulnerability to physical damage.

The lower the unit of a product the higher the total solid content will be. Products subjected to CSBe had the highest total solids values (Table 3), soluble solids (Table 4), weight loss (Table 5), and less pulp firmness (Table 5). This treatment also showed the lowest score of overall appearance (Table 6) and texture (Table 5). Water content reduction in a product certainly influences the overall appearance thereof, causing rejection by the judges after 19 days of storage (Table 6 and 7).

TABLE 3. Average values of moisture and total solids in fruit of 'Sweet Grape' mini tomato during storage.

TMT	Days of storage (DS)				Days of storage (DS)			
	0	8	19	33	0	8	19	33
	Moisture (%)				Total solids (%)			
Ce	92.12 Aa	90.57 Aab	-	-	7.88 Aa	9.43 Aab	-	-
Cr	92.12 Aa	91.96 Aab	92.21 Aa	92.29 Aa	7.88 Aa	8.04 Aab	7.79 Aa	7.71 Aa
PVCe	92.12 Aa	93.07 Aa	93.11 Aa	91.92 Aa	7.88 Aa	6.93 Ab	6.89 Aa	8.08 Aa
PVCr	92.12 Aa	91.26 Aab	91.74 Aa	92.60Aa	7.88 ABa	8.74 Aab	8.26 Aa	7.40 Aa
LDPEe	92.12 Aa	91.55 Aab	91.98 Aa	92.28 Aa	7.88 Aa	8.45 Aab	8.02 Aa	7.72 Aa
LDPEr	92.12 Aa	91.03 Aab	91.28 Aa	91.98 Aa	7.88 Aa	8.97 Aab	8.72 Aa	8.02 Aa
TFBe	92.12 Aa	90.85 Aab	-	-	7.88 Aa	9.15Aab	-	-
TFBr	92.12 Aa	91.58 Aab	92.63 Aa	-	7.88 Aa	8.42 Aab	7.37 Aa	-
CSBe	92.12 Aa	89.50 Bb	-	-	7.88 Ba	10.50 Aa	-	-
CSBr	92.12 ABa	91.23 Bab	92.55 Aa	-	7.88 ABa	8.77 Aab	7.45 Ba	-
CWe	92.12 Aa	91.22 Bab	92.23 Aa	-	7.88 Ba	8.78 Aab	7.77 Ba	-
CWr	92.12 Aa	91.87 Aab	92.74 Aa	92.41 Aa	7.88 Aa	8.13 Aab	7.26 Aa	7.59 Aa

Control under environmental conditions (Ce) and under refrigerated conditions (Cr); Polyvinyl Chloride flexible film under environmental (PVCe) and refrigerated (PVCr) conditions; Low Density Polyethylene under environmental (LDPEe) and refrigerated (LDPEr) conditions; Tomato Fruit biofilm under environmental (TFBe) and refrigerated (TFBr) conditions; Cassava starch biofilm under environmental (CSBe) and refrigerated (CSBr) conditions; Carnauba wax under environmental (CWe) and refrigerated (CWr) conditions. Treatments (TMT).

Means followed by different uppercase letters within the same line and lowercase within the same column differ from each other at 1% probability by the Tukey test.

- Treatments discarded by sensory tests.

With a few exceptions, there was fluctuation in soluble solids (Table 4) for all treatments during the storage. It might have happened due to uneven ripening of the samples and because of the raw material characteristics. Fruit intrinsic factors, such as transpiration processes, temperature, among others point out an increase in sugar metabolism consumed by fruit respiration. Garcia et al. (2012) also confirmed this process in fresh-cut strawberry. Nonetheless, soluble solids content tends to increase with fruit ripening through biochemical processes of polysaccharide degradation, which occurred in a study carried out by ŽNIDARČIČ et al. (2010) in tomato cultivar Belle.

TABLE 4. Average value of soluble solids and SS/ TA ratio in fruit of ‘Sweet Grape’ mini tomato during storage.

TMT	Days of storage (DS)				Days of storage (DS)			
	0	8	19	33	0	8	19	33
	Soluble solids (ºBrix)				SS/ TA ratio			
Ce	7.63 Aa	7.50 Aabc	-	-	13.74 Aa	13.98 Aabc	-	-
Cr	7.63 Aa	6.67 Bc	6.87 Ba	6.77 Bab	13.74 ABa	11.91 Ba	13.23 ABc	14.28 Ac
PVCe	7.63 Aa	7.67 Aab	7.67 Ba	6.57 Bb	13.74 Ca	15.80 BCa	16.67 Bab	19.51 Aa
PVCr	7.63 Aa	6.93 Abc	6.93 Aa	7.03 Aab	13.74 Ba	14.13 Bab	14.73 Bbc	17.46 Ab
LDPEe	7.63 Aa	7.47 Aabc	7.47 Aa	6.67 Aab	13.74 Ba	14.77 Bab	17.85 Aa	19.60 Aa
LDPEr	7.63 ABa	7.20 Babc	7.20 Aa	7.27 Ba	13.74 Ca	14.45 BCab	15.63 Babc	17.45 Ab
TFBe	7.63 Aa	7.77 Aab	-	-	13.74 Ba	14.56 Aab	-	-
TFBr	7.63 Aa	6.87 Bbc	7.17 Ba	-	13.74 Aa	13.08 Abc	13.50 Ac	-
CSBe	7.63 Ba	7.93 Aa	-	-	13.74 Aa	14.11 Aab	-	-
CSBr	7.63 Aa	7.03 Aabc	7.53 Aa	-	13.74 Aa	13.83 Aabc	14.22 Abc	-
CWe	7.63 Aa	7.33 Aabc	7.27 Aa	-	13.74 Aa	13.76 Aabc	13.82 Ac	-
CWr	7.63 Aa	6.70 Bc	7.23 ABa	6.43 Bb	13.74 Aa	12.79 Abc	13.35 Ac	13.67 Ac

Control under environmental conditions (Ce) and under refrigerated conditions (Cr); Polyvinyl Chloride flexible film under environmental (PVCe) and refrigerated (PVCr) conditions; Low Density Polyethylene under environmental (LDPEe) and refrigerated (LDPEr) conditions; Tomato Fruit biofilm under environmental (TFBe) and refrigerated (TFBr) conditions; Cassava starch biofilm under environmental (CSBe) and refrigerated (CSBr) conditions; Carnauba wax under environmental (CWe) and refrigerated (CWr) conditions. Treatments (TMT).
Means followed by different uppercase letters within the same line and lowercase within the same column differ from each other at 1% probability by the Tukey test.
- Treatments discarded by sensory tests.

One of the outstanding features of ‘Sweet Grape’ tomatoes is the high content of soluble solids; thereby, we observed a minimum of 6.43 ºBrix for Cr at 33 DS and a maximum of 7.93 °Brix for CSBe at 8 DS (Table 4). However, these values were lower than those obtained by ALESSI (2010) of 8.67 °Brix, and by ABRAHÃO et al. (2011a) of 7.9 to 8.5 ºBrix, for the same cultivar of mini tomato. At the end of lifespan, Cr, PVCe, TFBr, and Cr were lower at day zero, and among the treatments that reached 33 DS, only LDPEr was higher than PVCe and CWr.

Overall, with a few exceptions, oscillations occurred in the ratio (Table 4) during storage, ranging from 11.91 for Cr at 8 DS up to 19.60 for LDPEe at 33 DS (Table 4). ALESSI (2010), for this same cultivar, observed an average of 13.80 and ABRAHÃO et al. (2011a) noted a variation between 17.90 and 19.30, denoting an excellent taste as the ratio value exceeded 10.

The high value of the relationship soluble solid and acidity titratable is a measure of taste and indicates an excellent combination of sugar and acid that depict a sweet taste, while low values stand for acid. Thus, SS/ TA ratio represents the balance between sweet and sour, giving a good evaluation of the fruit "sweetness" (PANTOJA et al., 2009). After 33 DS, fruits submitted to CWr presented lower values of titratable acidity and soluble solids, resulting in lower value of SS/ TA for this period. Differences in lifespan relative to day zero were observed for PVCe, PVCr, LDPEe, and LDPEr. However, for treatments that achieved 33 days of storage, PVCe LDPEe got values higher than the other treatments did.

The greatest loss of weight until the end of fruit shelf life was 14.80% for CSBe at 8 DS, which did not differ from Ce. Therefore, transpiration has not reduced without a consequent loss of mass. PRATES & ASCHERI (2011) found similar findings in strawberry fruit. Tomatoes coated with *lobeira* tomato and cassava starch coatings had higher mass loss, and CSBe achieved a loss of weight greater than the control (uncoated) kept under ambient conditions. OLIVEIRA et al. (2011) confirmed this result in table tomatoes. Conversely, QUEIROZ et al. (2010) noted that cassava starch coating at 2 and 4% retained more fresh mass of baby corn (AG 1051 cultivar), indicating positive effects of such treatment on postharvest storage.

Furthermore, PVCr and LDPEr at 33 DS promoted the minor weight losses of approximately 0.42% and 0.43%, respectively. Whereas the largest loss on the same date was observed for Cr (13.25%), being significantly higher than the other treatments (Table 5). Such efficiency of PVC and LDPE materials to decrease weight loss must be due to a reduction in fruit respiration rate, providing an important barrier against water loss and, consequently, increasing fruit shelf life, since we observed that Ce, TFBe, and CSBe had a lifespan of 8 DS. The mass loss is mainly caused by transpiration and becomes greater the higher the temperature and the longer the exposure of fruit to these conditions, which was confirmed in this study.

TABLE 5. Cumulative average values of fresh mass loss and firmness of mini tomato fruit cultivar 'Sweet Grape' throughout storage.

TMT	Days of storage (DS)				Days of storage (DS)			
	0	8	19	33	0	8	19	33
	Fresh mass loss (%)				Firmness (N)			
Ce	0.00 Ba	14.14 Aa	-	-	24.36 Aa	9.71 Aabcd	-	-
Cr	0.00 Da	2.11 Cdef	4.56 Bb	13.25 Aa	24.36 Aa	5.64 Abcd	9.34 Aa	8.33 Aa
PVCe	0.00 Da	0.90 Cfg	2.02 Bc	3.52 Ab	24.36 Aa	6.30 Aabcd	10.39 Aa	9.54 Aa
PVCr	0.00 Da	0.08 Cg	0.24 Bd	0.42 Ac	24.36 Aa	6.62 Aabcd	7.51 Aa	9.35 Aa
LDPEe	0.00 Da	0.87 Cfg	2.03 Bc	3.41 Ab	24.36 Aa	7.96 Aabcd	7.66 Aa	12.26 Aa
LDPEr	0.00 Ca	0.10 Cg	0.21 Bd	0.43 Ac	24.36 Aa	10.68 Aabc	8.75 Aa	8.31 Aa
TFBe	0.00 Ba	12.27 Ab	-	-	24.36 Aa	4.26 Ad	-	-
TFBr	0.00 Ca	2.76 Bde	5.12 Ab	-	24.36 Aa	10.75 Aab	8.52 Aa	-
CSBe	0.00 Ba	14.80 Aa	-	-	24.36 Aa	5.01 Acd	-	-
CSBr	0.00 Ca	2.86 Bd	5.86 Ab	-	24.36 Aa	11.79 Aa	7.07 Aa	-
CWe	0.00 Ca	7.91 Bc	13.00 Aa	-	24.36 Aa	5.38 Abcd	7.66 Aa	-
CWr	0.00 Da	1.49 Cef	2.71 Bc	4.01 Ab	24.36 Aa	7.19 Aabcd	8.11 Aa	10.43 Aa

Control under environmental conditions (Ce) and under refrigerated conditions (Cr); Polyvinyl Chloride flexible film under environmental (PVCe) and refrigerated (PVCr) conditions; Low Density Polyethylene under environmental (LDPEe) and refrigerated (LDPEr) conditions; Tomato Fruit biofilm under environmental (TFBe) and refrigerated (TFBr) conditions; Cassava starch biofilm under environmental (CSBe) and refrigerated (CSBr) conditions; Carnauba wax under environmental (CWe) and refrigerated (CWr) conditions. Treatments (TMT).

Means followed by different uppercase letters within the same line and lowercase within the same column differ from each other at 1% probability by the Tukey test.

- Treatments discarded by sensory tests.

Table 5 shows that the firmness of fruits lowered for all treatments from day zero (24.36 N) to the end of shelf life. This reduction displays ripening earliness, reaching a value of 8.31 N for LDPEr treatment, being more marked between 0 and 8 DS. This effect was markedly evidenced in treatments with biofilm and wax, reaching 82.51% for TFBe at 8 DS. This fluctuation may be due to an interaction among fruit, coating, and environment in each treatment. ŽNIDARČIČ et al. (2010) also observed a reduction in firmness of tomato fruit of Belle cultivar during storage at 5 ºC and 10 ºC for 28 days.

Even after 33 days stored, the treatments PVC, LDPE, LDPEr, and CWr were still accepted by the appraisers (scores> 5) on overall appearance (Table 6). Thus, these treatments achieved a longer lifespan than the other treatments. The lowest score (2.70) was assigned to PVCe, and the highest (8.80) to LDPEr at 8 DS.

TABLE 6. Average values of overall appearance and color of mini tomato fruit cultivar 'Sweet Grape' throughout storage.

TMT	Days of storage (DS)				Days of storage (DS)			
	0	8	19	33	0	8	19	33
	Overall appearance				Color			
Ce	7.80 Aa	5.10 Bd	-	-	8.00 Aa	6.90 Aab	-	-
Cr	7.80 Aa	8.10 Aabc	8.20 Aab	3.90 Bcd	8.00 ABa	7.90 ABab	8.30 Aa	6.30 Bab
PVCe	7.80 Aa	8.60 Aab	8.40 Aa	2.70 Bd	8.00 Aa	8.70 Aa	8.40 Aa	4.60 Bb
PVCr	7.80 Aa	8.50 Aab	8.20 Aab	7.20 Aab	8.00 ABa	8.60 Aa	8.30 ABa	6.70 Bab
LDPEe	7.80 ABa	8.60 Aab	6.30 BCbc	5.40 Cbc	8.00 ABa	8.50 Aa	7.10 ABab	6.60 Bab
LDPEr	7.80 ABa	8.80 Aa	7.30 ABab	6.80 Bab	8.00 Aa	8.60 Aa	7.40 Aab	7.00Aab
TFBe	7.80 Aa	4.80 Bd	-	-	8.00 Aa	6.20 Ab	-	-
TFBr	7.80 Aa	6.60 ABbcd	4.50 Bcd	-	8.00 Aa	6.90 Aab	6.10 Ab	-
CSBe	7.80 Aa	4.90 Bd	-	-	8.00 Aa	6.30 Bb	-	-
CSBr	7.80 Aa	6.10 ABcd	4.60 Bcd	-	8.00 Aa	6.90 Aab	6.20 Ab	-
CWe	7.80 Aa	7.70 Aabc	3.50 Bd	-	8.00 Aa	7.80 ABab	6.10 Bb	-
CWr	7.80 Aa	7.90 Aabc	7.80 Aab	8.20 Aa	8.00 Aa	7.80 Aab	7.80 Aab	7.90 Aa

Control under environmental conditions (Ce) and under refrigerated conditions (Cr); Polyvinyl Chloride flexible film under environmental (PVCe) and refrigerated (PVCr) conditions; Low Density Polyethylene under environmental (LDPEe) and refrigerated (LDPEr) conditions; Tomato Fruit biofilm under environmental (TFBe) and refrigerated (TFBr) conditions; Cassava starch biofilm under environmental (CSBe) and refrigerated (CSBr) conditions; Carnauba wax under environmental (CWe) and refrigerated (CWr) conditions.

Means followed by different uppercase letters within the same line and lowercase within the same column differ from each other at 1% probability by the Tukey test.

- Treatments discarded by sensory tests.

In general, scores decreased with storage time, except for PVCr and CWr. Even confirming the end of shelf life of fruit based on overall appearence, color was accepted by the judges, except for PVCe at 33 DS, which obtained score of 4.60, differing from the other treatments, while the other treatments had scores above 6.10. Nevertheless, similarly to overall appearence judgement, there was a decrease in scores for color in all treatments (Table 6). During tomato ripening, chlorophyll is degraded with gradual synthesis of lycopene, which is responsible for the red color; however, it was not as intense as that observed by RINALDI et al. (2011) for tomato of Dominator cultivar.

At the end of shelf life, appraisers accepted PVCr, LDPEe, LDPEr, TFBr, CSBr, and CWr regarding fruit texture (Table 7). Texture is one of the most important quality attributes in vegetables. Pectic substances, which are the major chemical components of tissue, directly influence fruit texture; such textural alterations can be minimized at low temperatures. Ce, TFBe, and CSBe had the lowest lifespan (less than 8 DS). CWr received the highest score (7.40) for fruit texture at 33 DS.

As observed for texture scoring, aroma scores decreased over the storage time. In the end, for treatments that reached a lifespan of 33 DS, only PVCe received scores above 5.0, differing from the other treatments; and the highest score (6.90) was for CWr (Table 7). We noticed that refrigeration may have assisted in taste maintenance and, in general, fruit kept under refrigeration received higher scores when compared to those under environmental condition.

TABLE 7. Average values of fruit texture and aroma in mini tomato cultivar ‘Sweet Grape’ throughout storage.

TMT	Days of storage (DS)				Days of storage (DS)			
	0	8	19	33	0	8	19	33
	Texture				Aroma			
Ce	8.50 Aa	4.80 Bbc	-	-	7.50 Aa	5.40 Ba	-	-
Cr	8.50 Aa	7.70 Aa	8.10 Aa	4.10 Bb	7.50 Aa	6.80 ABa	8.10 Aa	5.40 Bab
PVCe	8.50 Aa	8.20 Aa	7.90 Aa	5.00 Bab	7.50 Aa	7.30 Aa	7.00 Aa	4.10 Bb
PVCr	8.50 Aa	7.80 Aa	7.40 Aa	6.60 Aab	7.50 Aa	7.20 Aa	6.60 Aab	6.10 Aab
LDPEe	8.50 Aa	8.30 ABa	6.70 Ca	6.90 BCa	7.50 Aa	7.00 Aa	5.50 Ab	5.50 Aab
LDPEr	8.50 Aa	8.30 ABa	6.90 BCa	6.70 Cab	7.50 Aa	7.40 Aa	6.10 Aab	6.00 Aab
TFBe	8.50 Aa	4.10 Bc	-	-	7.50 Aa	4.80 Ba	-	-
TFBr	8.50 Aa	6.90 ABab	6.20 Ba	-	7.50 Aa	5.70 ABa	5.40 Bb	-
CSBe	8.50 Aa	4.30 Bc	-	-	7.50 Aa	5.40 Ba	-	-
CSBr	8.50 Aa	7.10 ABa	6.30 Ba	-	7.50 Aa	6.00 Aa	5.60 Ab	-
CWe	8.50 Aa	7.00 Aa	3.80 Bb	-	7.50 Aa	6.10 ABa	4.90 Bb	-
CWr	8.50 Aa	8.10 Aa	7.90 Aa	7.40 Aa	7.50 Aa	7.00 Aa	6.90 Aab	6.90 Aa

Control under environmental conditions (Ce) and under refrigerated conditions (Cr); Polyvinyl Chloride flexible film under environmental (PVCe) and refrigerated (PVCr) conditions; Low Density Polyethylene under environmental (LDPEe) and refrigerated (LDPEr) conditions; Tomato Fruit biofilm under environmental (TFBe) and refrigerated (TFBr) conditions; Cassava starch biofilm under environmental (CSBe) and refrigerated (CSBr) conditions; Carnauba wax under environmental (CWe) and refrigerated (CWr) conditions. Treatments (TMT).
Means followed by different uppercase letters within the same line and lowercase within the same column differ from each other at 1% probability by the Tukey test.
- Treatments discarded by sensory tests.

On the day zero, consumer's purchase intention (data not shown) for ‘Sweet Grape’ tomatoes had good results; however, this result was not the best of the entire experiment. The raw material cultivar ‘Sweet Grape’ had a percentage of 60% for the option "certainly buy". On the eighth day of storage, product acceptance was higher. Products without coatings (control) and those covered with *lobeira* and cassava starch biofilms under room temperature had percentages of 20% and 70% for the options "certainly would not buy" and "may buy / may not buy ", respectively at the end of their shelf life. These results show the level of demand by consumers regarding product quality.

On the nineteenth day of storage, fruit have reached the highest percentage for the option "certainly buy". Samples without packaging in cooled condition, and those coated with PVC at room temperature accounted for 80%. Right after, the highest percentages were for fruit covered with PVC (60%) and wax (50%) under cooling. Refrigerated treatments with biofilms and wax under environment condition had respectively 30% and 50% for the alternative "certainly would not buy". Samples coated with wax under refrigeration was the most attractive by the judges' evaluation, getting 60% for the option "certainly buy", and 40% would probably buy PVC coated refrigerated samples. Nonetheless, samples coated with PCV maintained at ambient conditions had the highest rejection rate, with 80% choosing the option "certainly would not buy".

In the nineteenth day of storage, the products have obtained the highest percentage for "certainly buy" option. Samples without packaging in a refrigerated condition and coated with PVC at room temperature accounted for 80% of this option; followed by fruits covered with PVC (60%) and wax (50%) under cooling. Refrigerated treatments with biofilm and wax at room temperature obtained respectively 30% and 50% for the alternative "certainly would not buy". The sample coated with wax under refrigeration was the most appreciated by the judges; these fruits have obtained 60% for the option "certainly buy". About 40% would probably buy the PVC samples under refrigeration. However, PVC coated samples maintained at ambient conditions were those with the highest rejection rate, with 80% choosing for "certainly would not buy". Food sensory tests are very important since they provide essential information for production and marketing of these products with regard to consumers' demands and preferences (SILVA et al., 2010).

CONCLUSIONS

Fruit of mini tomatoes cultivar ‘Sweet Grape’ submitted to the treatments PVCr, LDPEe, LDPEr, and CWr achieved a shelf life of 33 days of storage. Starch biofilms of both *lobeira* fruit and cassava are not effective in reducing fresh mass losses. Refrigeration is the best condition for postharvest preservation of mini tomatoes. Fruit packed with carnauba wax left under refrigeration most pleased the judges (consumers), while PCV-packed fruit had the highest rejection rate.

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