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QUALITY OF NAPOLI CV. EGGPLANT COATED WITH CARNAUBA WAX

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ABSTRACT

The objective of this study was to evaluate the quality of eggplant Napoli cv. coated with Carnauba wax and stored for seven days at room temperature. Treatments consisted of immersion of fruits in two concentrations of two types of commercial wax, totaling four treatments: Meghwax ECF 124 to 9% concentrations (Megh 9%); Meghwax ECF 124 to 18% (Megh 18%), Arua BR 18% (*Pomacea canaliculata*) Tropical 9% (Arua 9%), and Arua BR 18% Tropical 18% (Arua 18%). The control treatment consisted of fruit without coating with wax and immersed in water. Fruits were analyzed at 0, 3, 6, and 7 days for the outer appearance, weight loss, turgor pressure, titratable acidity (TA), soluble solids (SS), SS/TA ratio, ascorbic acid, and pH. The waxes were effective in reducing weight loss. The turgor pressure showed a decrease during storage, which was more pronounced in the control treatment. The treatments did not differ among themselves for the levels of soluble solids. Fruits immersed in Arua wax at 18% concentration showed higher titratable acidity. The levels were reduced during storage. The control fruits showed higher pH. The ascorbic acid contents decreased by 15.0%, 16.4%, 16.5%, 16.9%, and 34%, considering the control treatments. Fruits subjected to Arua wax at 18% had longer shelf-life; the control fruits showed shorter shelf-life. Thus, it is concluded that 18% Aruá wax was the most effective to increase the shelf life of eggplants when stored at room temperature.

Palavras-chave:
Frutos
vida útil
Solanum melongena L.

QUALIDADE DE BERINJELAS CV. NÁPOLI REVESTIDAS COM CERA DE CARNAÚBA

RESUMO

Objetivou-se avaliar neste trabalho a qualidade de berinjelas cv. Nápoli revestidas com cera de carnaúba, armazenadas por 7 dias sob temperatura ambiente. Os tratamentos consistiram na imersão dos frutos em duas concentrações em dois tipos de cera comercial, totalizando quatro tratamentos: Meghwax ECF 124 a 9% (9% Megh), Meghwax ECF 124 a 18% (18% Megh), Aruá BR18% Tropical a 9% (9% Aruá) e Aruá BR18% Tropical a 18% (18% Aruá). O tratamento controle foi de frutos sem recobrimento com cera e imersos em água. Os frutos foram avaliados aos 0, 3, 6 e 7 dias quanto à aparência externa, perda de massa, pressão de turgescência, acidez titulável (AT), sólidos solúveis (SS), relação SS/AT, ácido ascórbico e pH. As ceras foram eficientes na redução da perda de massa. A pressão de turgescência reduziu-se ao longo do armazenamento, mais acentuada no tratamento controle. Os tratamentos não diferiram quanto aos teores de sólidos solúveis. Os frutos imersos em cera Aruá a 18% apresentaram maiores valores de acidez titulável. Esses teores reduziram com o armazenamento. Os frutos controle apresentaram maior pH. Os teores de ácido ascórbico apresentaram redução de 15,0 16,4; 16,5; 16,9; e 34%, considerando os tratamentos controle. Os frutos submetidos à cera 18% Aruá apresentaram maior vida útil, enquanto os controles, a menor. Sendo assim, conclui-se que a cera Aruá a 18% foi a mais eficaz para aumentar a vida útil de berinjelas quando armazenadas na temperatura ambiente.

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INTRODUCTION

Post-harvest losses of fruits and vegetables occur with great intensity in several countries, such as Brazil. However, it is evident that in developed countries these losses are smaller than those of low/medium income (GUSTAVSSON et al, 2011).

Eggplant (*Solanum melongena* L.) stands out as a vegetable of great importance on the Brazilian panorama. It is widely consumed in tropical and subtropical countries, with worldwide production of around 49 million tons (FAOSTAT, 2016). In the state of São Paulo, the area used for planting this food in 2017 was approximately 1.4 thousand ha (IEA, 2018).

This vegetable has several important health benefits and its consumption can be stimulated due to its nutritional factors. A wide range of nutrients is found in this food, such as vitamins, phenolic compounds, antioxidants and minerals, which assist the body in fighting diseases, in addition to reducing plasma cholesterol in the bloodstream (GURBUZ et al., 2018).

Eggplants are usually commercialized in retail stores, fairs and supermarkets, in their fresh form, with no humidity or temperature control. Post-harvest food preservation is essential to maintain the shell-life of the product. Studies indicate that lower temperature helps to extend storage time (SANTOS et al., 2018).

Vegetables and fruits are susceptible to post-harvest losses, one of the biggest issues in the production chain, which is a concern of the society. These losses are associated with several mechanical injuries caused by transportation, the use of inappropriate packaging for certain foods and incorrect handling (GUERRA et al., 2017).

To preserve quality and extend shelf-life, the modified atmosphere (MA) is one of the most used methods, as concentration of O_2 is reduced and CO_2 is increased, resulting in a reduction in the growth of microorganisms, respiration and perspiration and ethylene production. Carnauba wax controls the gas exchange between the fruit and the environment that surrounds it, being used to improve the visual aspect by providing a shiny appearance and reducing the respiratory activity of the fruits, being a treatment to be used to maintain the shelf-life of highly perishable vegetables (SINGH et al., 2016).

The application of Carnauba wax in fruits and vegetables, either by immersion or spraying, reduces the consequences of physical damage and rot. In addition, it is efficient in reducing post-harvest losses, being a low-cost alternative for small producers (ARTHUSO et al., 2009).

Souza et al. (2009) concluded that PVC films and cassava-starch biofilms increased the shelf-life of Embu cultivar eggplants. According to Henz et al. (2006), eggplant should not be stored at temperatures below 8°C so injury by cold does not occur, as it is a tropical fruit, and the lesion will depend on the time of exposure to that temperature.

Eggplants commercialized in Brazil are generally not refrigerated and sold in bulk, factors that cause undesirable changes in a few days, such as wilting and loss of shine (Henz; Silva, 1995).

Due to these changes that result in loss of nutritional and commercial value, the objective of this work is to evaluate the quality of Nápoli cultivar eggplants submitted to different types and concentrations of wax, stored in room conditions.

MATERIAL AND METHODS

Napoli cv. eggplants were harvested manually on March 19, 2012, when they had completed their physiological development on an agricultural property located in the municipality of Goiânia, State of Goiás (GO) (16°40'S and 49°16'W) and carefully packed in a cardboard box (39x31x15 cm) for transportation to the Fruit and Vegetable Laboratory of IF Goiano - Rio Verde campus. The fruits were selected according to their size, color and absence of mechanical injuries, sanitized in chlorinated water (100mg L^{-1}) for three minutes, and separated into five homogeneous lots, with 58 fruits, which corresponded to the following treatments: control (fruits not subjected to wax); 9% Aruá (fruits immersed in Aruá BR18%

Tropical wax at 9% concentration); 18% Aruá (fruit immersion in Aruá BR18% Tropical wax at 18%); 9% MEGH (fruits immersed in Meghwax ECF 124 at 9%); and 18% MEGH (fruits immersed in Meghwax ECF 124 at 18%). The waxes were diluted according to the manufacturer's instructions, in order to guarantee 9% and 18% of actives. The fruits submitted to the different treatments were stored in a laboratory environment with temperature and relative humidity ranging from 26 to 29ºC and humidity from 45 to 80% RH.

The fruits were evaluated at 0, 3, 6 and 7 days, in four repetitions, with three fruits each according to the following parameters: appearance, loss of fresh weight, turgor pressure, soluble solids and titratable acidity, ratio, ascorbic acid and pH. For the evaluation of appearance and mass loss, a batch with 10 fruits of each treatment was reserved, which allowed to evaluate the evolution of these parameters over the storage period, always using the same fruits. The evaluation period was delineated by observing the evolution of the appearance of the fruits, discarding them when considered unfit for consumption.

Appearance was assessed using a subjective scale, considering the presence or absence of wilting or rot, ranging from 0 to 3, where 3 = good quality (shiny fruits and wilting no noticeable to the touch), 2 = regular quality (shiny and with wilting barely perceptible to touch), 1 = poor quality (shiny and with noticeable wilting to the touch) and 0 = terrible quality (shiny and with marked wilting and beginning of rot), while the fruit weight loss was assessed with the aid of a digital scale, with a precision of two decimal places, the results expressed as a percentage of the initial mass.

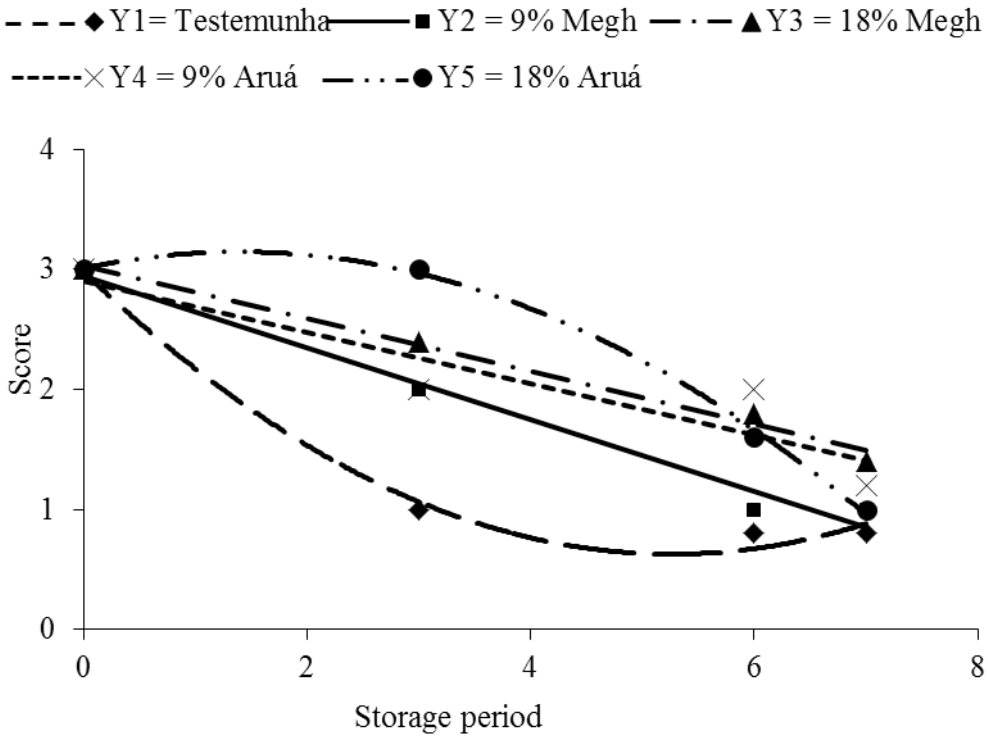
The turgor pressure was determined by means of the applanation technique, using a horizontal planer (Calbo and Nery, 1995), and the results were expressed in kgf cm^{-2}. The analyses of the contents of titratable acidity, soluble solids and pH were determined according to IAL methodologies (2008). The titratable acidity levels were obtained by titrating the filtered juice with NaOH solution (0.1N), and the results, expressed in% citric acid. The filtered juice was read in an Atago N-2E refractometer at the determination of the content of soluble solids, expressed in °Brix. The ratio was determined by the Brix/total acidity relation. The pH was determined using a Bel Engineering potentiometer, model W3B. The levels of ascorbic acid were determined through redox volume reduction, with titration of the samples with 2,6-dichloro-phenolindophenolsodic solution (DCFI), according to the AOAC methodology (2000).

The shelf-life was determined taking into account the physical and chemical characteristics of the fruits, which was limited when the appearance had a score of 2 (shiny fruits and with withering barely perceptible to the touch).

The experimental design was completely randomized and the results were analyzed using a 5 x 4 factorial scheme, consisting of five treatments (control, 9% Megh, 18% Megh, 9% Aruá and 18% Aruá) and four storage periods (0; 3; 6 and 7 days). The data obtained for the weight loss and appearance variables as a function of storage period were analyzed using polynomial regression. The models were selected according to the coefficient of determination and their significance by the F test. The statistical program (software) used was ESTAT from FCAV/Unesp.

RESULTS AND DISCUSSION

The appearance evolved from good (score = 3) to regular (score= 2) in the first three days of storage, when the fruits were immersed in Megh wax at 9% or 18% and Aruá at 9%, but when immersed in Aruá wax at 18%, the appearance remained good over this period. The fruits submitted to the wax, regardless of the brand and concentration, showed a better appearance than the fruits in the control group, which were unfit for consumption (score = 1) after one day of storage (Figure 1). The occurrence of rot was recorded only on the sixth day in the control fruits and in those treated with 9% Megh wax. As an edible material, wax restricts the diffusion of moisture and gases, such as oxygen

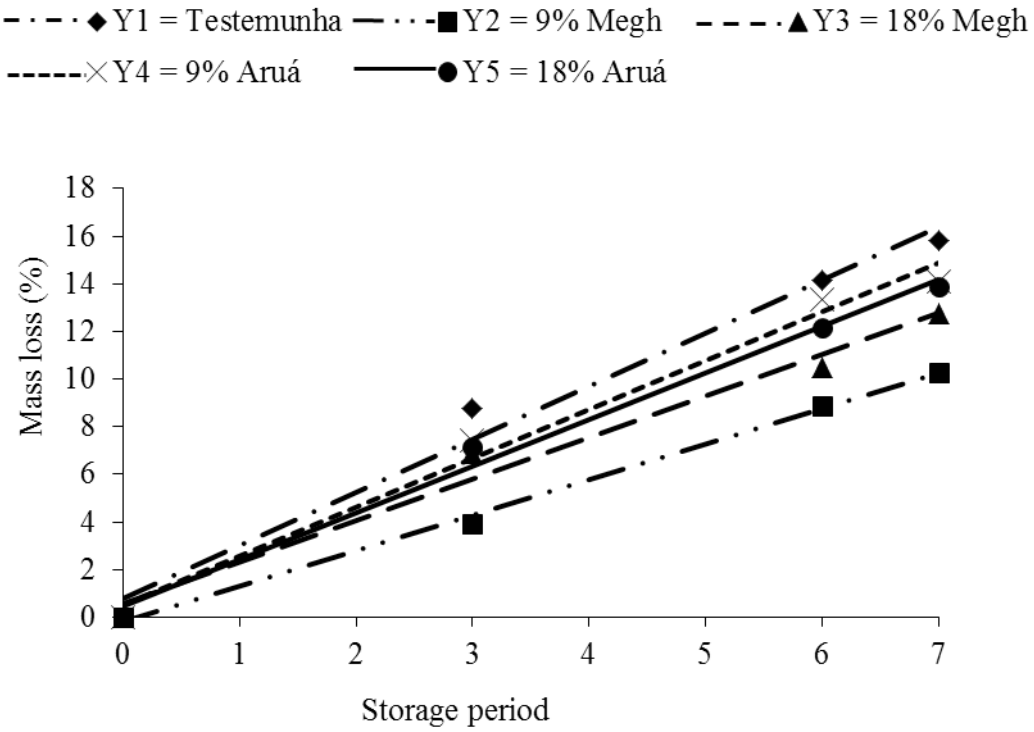


$Y1 = 0.0848x^2 - 0.8939x + 2.9818;\ R^2 = 0.9921$
$Y2 = -0.3x + 2.95;\ R^2 = 0.9818$
$Y3 = -0.22x + 3.03;\ R^2 = 0.9878$
$Y4 = -0.2133x + 2.9033;\ R^2 = 0.8376$
$Y5 = -0.0697x^2 + 0.1945x + 3.0097;\ R^2 = 0.9975$

Figure 1. Evolution of the appearance in eggplants subjected to different concentrations of carnauba wax, stored at 26-29°C and 45-80% RH, for up to 7 days. The shelf-life the fruits was limited by score 2 (shiny and with withering barely noticeable to the touch). * Witness = Control.

and carbon dioxide, thus preventing weight loss of the food and maintaining a shiny appearance (CHEN; SUN; YANG; 2019), a decisive factor in the purchase preference by the consumer, since it maintains the conservation of the food. The short conservation period observed in this experiment may be associated with the high temperature and low relative humidity of the air that may have led to an increase in mass loss (CHITARRA & CHITARRA, 2005), reflected in the appearance of the fruits. The respiration of the fruit is an important factor for weight loss, since heat is generated over the respiration process, which causes a raise in temperature in the fruit, increasing transpiration. Thus, the increase in the respiratory frequency of food directly contributes to weight loss during storage (THAKUR et al, 2018). As in this study, Menezes et al (2017) also showed weight loss in all treatments in the post-harvest quality of table tomatoes (*Solanum lycopersicum*) wrapped in different coatings.

All fruits lost mass over storage. The control treatment showed the highest loss (15.8%) and the 9% Megh treatment had the lowest (10.29%). After seven days of storage, the mass loss was 15.8%, 10.29%, 12.76%, 14.11% and 13.88% for the control, 9% Megh, 18% Megh, 9% Aruá and 18% Aruá treatments, respectively (Figure 2). According to the results, all treatments with wax were more effective than the control in reducing mass loss, corroborating the data found by Onias et al., (2018) who evaluated the post-harvest of



$Y1 = 2.2303x + 0.7562;\ R^2 = 0.9826$
$Y2 = 1.4877x - 0.1807;\ R^2 = 0.9975$
$Y3 = 1.7447x + 0.5563;\ R^2 = 0.9803$
$Y4 = 2.0547x + 0.5013;\ R^2 = 0.9869$
$Y5 = 1.9593x + 0.4602;\ R^2 = 0.9916$

Figure 2. Evolution of mass loss in eggplants subjected to different concentrations of Carnauba wax, stored at 26 to 29°C and 45-80% RH, for up to 7 days.

guava Paluma with *Spirulina platensis*-based biodegradable coating.

The fruits submitted to the different wax treatments did not differ from each other and from the control fruits in relation to turgor pressure (Table 1). The fruits immersed in 18% Aruá wax showed higher values of titratable acidity (0.0766 g of citric acid $100g^{-1}$), while the other treatments did not differ from the control fruits in terms of these levels (Tables 1 and 2). The turgor pressure was reduced from 0.4370 to 0.1260 $kgf.cm^{-2}$ (Table 1) during storage, while the titratable acidity showed a reduction trend from the third day of storage, reaching values of 0.0695 mg of citric acid $100g^{-1}$ (Tables 1 and 2).

The treatments did not differ from each other in terms of soluble solids, which practically did not change during storage (Table 1). Only on the third day of storage was it possible to observe a decrease in this value. However, the relationship between treatment and time was not significant. This behavior was also observed by Thakur et al. (2018) in plums (*Prunus salicina*) coated with edible coating based on rice starch, according to the authors, the coating material did not show negative impacts to the food. Menezes et al. (2017) found an increase in this content throughout the storage period in table tomatoes when coated with cassava starch or corn starch in 12 days of storage. Thus, they managed to delay the ripening process of this fruit.

The fruits immersed in the different wax brands and concentrations did not differ from the control fruits in relation to the ratio values, except for those submitted to the 18% Aruá wax, which had lower ratio values (4.39). The ratio values increased

over storage, due to the decrease in the levels of acidity (Table I). The results found in this study differ from those found by Junior et al. (2010) in which the ratio values decreased significantly over the storage of hybrid pepper Zarco (*Capsicum annuum* L.) at the stage of green-yellow maturation at 26.4°C. Therefore, it can be understood that there was a greater control in gas exchanges with external medium, leading to a slow maturation in the eggplants in this study.

The treatments did not differ from each other in relation to the levels of ascorbic acid, which showed a reduction trend over storage when the fruits were submitted to Megh and or Aruá wax at 18% (Tables I and III). Souza et al. (2009) showed a tendency to stabilize during the storage of eggplants coated with cassava-starch or PVC film. The analysis of ascorbic acid is important for the quality content of the food. Eggplants generally have low levels of ascorbic acid when compared to other vegetables. According to Quirino et al. (2018) the vitamin C content decreased over the study period in guavas (*Paluma*) coated with cassava-starch and pectin.

The pH of the eggplant fruits differed between treatments, with the control showing the highest value (6.22) and the other treatments did not differ between them. The pH values varied during storage, showing an increasing trend.

However, these results are in agreement with that found by Pizato et al. (2013) in which a tendency was shown towards a reduction in pH in samples of minimally processed apples in different treatments over a 15-day storage period. The fruits have an average pH of 4.26 to 4.98, which is lower than the values of this study. Fontes et al. (2008), when analyzing minimally processed apples with coated films, showed that some edible coatings kept the pH of the fruits unchanged during storage. Values of pH are indicated as microbiota markers in food for conservation (NASSER et al. 2018).

Table 1. Average values of turgor pressure, titratable acidity (TA), soluble solids (SS), ratio, ascorbic acid (AA) and pH of Napoli cv. eggplants coated with Carnauba wax, stored at 26-29°C and 45-80% RH.

Treatment	Pressure	TA	SS	Ratio	A. A	pH
Control	0.1988a	0.0637b	5.11a	5.28a	12.571a	6.22a
9% Megh	0.2313a	0.0684ab	5.04a	4.92ab	12.901a	6.17ab
18% Megh	0.2231a	0.0723ab	4.96a	4.59ab	11.775a	6.16ab
9% Aruá	0.2106a	0.0707ab	5.03a	4.72ab	12.631a	6.14b
18% Aruá	0.2406a	0.0766a	5.06a	4.39b	11.621a	6.17ab
F test	1.7290 NS	3.2946*	0.7837 NS	3.1068 *	1.7138 NS	2.9510 *
SAD (5%)	0.0501	0.0104	0.2462	0.7673	1.7198	0.0668
Period (day)						
0	0.4370a	0.0818a	5.08[a]	4.07c	13.274a	6.01c
3	0.1885b	0.0695b	4.85b	4.62bc	13.125a	6.29a
6	0.1320c	0.0666b	5.15a	5.43a	12.175a	6.09b
7	0.1260c	0.0636b	5.10a	5.00ab	10.625b	6.30a
F test	169.7901 **	11.672 **	5.8014 **	11.2925 **	9.9313 **	92.3907 **
SAD (5%)	0.0421	0.0088	0.2070	0.6449	1.4455	0.0561
Treatment x period	1.9036 NS	2.2500 *	1.5224 NS	3.3668 **	4.0647 **	2.4020 *
CV (%)	22.8120	14.9114	4.9105	16.1349	14.0528	1.0871

Means followed by at least one lowercase letter in the columns do not differ by test of Tukey (P <0.05).

Table 2. Titratable acidity of Napoli cv. eggplants coated with Carnauba wax, stored at 26-29°C and 45-80% relative humidity.

Period (day)	Control	9% Megh	18% Megh	9% Aruá	18% Aruá
0	0.0740aA	0.076aA	0.086aA	0.0825aA	0.091aA
3	0.0665aA	0.074aA	0.0743abA	0.0595bA	0.073abA
6	0.0580aBC	0.0495bC	0.060bABC	0.0712abAB	0.079abA
7	0.0562aA	0.074aA	0.0695abA	0.0695abA	0.063bA

Means followed by at least one lowercase letter in the columns and at least one uppercase letter in the lines do not differ by test of Tukey (P <0.05).

Table 3. Contents of ascorbic acid of Napoli cv. eggplants coated with carnauba wax, stored at 26-29°C and 45-80% relative humidity.

Period (day)	Control	9% Megh	18% Megh	9% Aruá	18% Aruá
0	13.095aA	11.603bcA	14.288aA	14.588aA	12.798abA
3	13.125aA	14.688abA	11.25abA	12.5abA	14.063aA
6	12.813aAB	15.625aA	12.188abABC	11.25bBC	9.00cC
7	11.250aA	9.688cA	9.375bA	12.188abA	10.625bcA

Means followed by at least one lowercase letter in the columns and at least one uppercase letter in the lines do not differ by test of Tukey (P <0.05).

Table 4. Values of pH of Nápoli cv. Eggplants coated with Carnauba was, stored at 26-29°C and 45-80% of relative humidity.

Period (day)	Control	9% Megh	18% Megh	9% Aruá	18% Aruá
0	6.05bA	6.07cA	6.02bA	5.96bA	5.98bA
3	6.43aA	6.22abB	6.25aB	6.22aB	6.32aAB
6	6.05bA	6.10bcA	6.10bA	6.08bA	6.10bA
7	6.36aA	6.30aA	6.28aA	6.31aA	6.26aA

Means followed by at least one lowercase letter in the columns and at least one uppercase letter in the lines do not differ by test of Tukey (P <0.05).

CONCLUSION

The use of 18% Aruá carnauba wax is recommended for the storage of eggplants because it increases the shelf-life by four days, at room temperature.

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