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SHELF LIFE OPTIMIZATION *PHYSALIS IXOCARPA* WITH BEE HONEY SPRAYED IN PRODUCTION: AN INNOVATIVE APPROACH

Felipe de Jesús González Rodríguez
``Instituto Tecnológico Superior de Calkiní Campeche``, Mexico
ORCID 0000-0002-2360-3977

Mario Ben-Hur Chuc Armendáriz
``Instituto Tecnológico Superior de Calkiní Campeche``, Mexico
ORCID 0000-0002-6629-1168

Gonzalo Miguel Quetz Aguirre
``Instituto Tecnológico Superior de Calkiní Campeche``, Mexico
ORCID 0000-0002-2848-1075

Marlene Méndez Moreno
``Instituto Tecnológico Superior de Calkiní Campeche``, Mexico
ORCID 0000-0002-7846-912x

Ángel Francisco Can Cabrera
``Instituto Tecnológico Superior de Calkiní Campeche``, Mexico
ORCID 0000-0002-6696-9899

Abstract: In the context of postharvest preservation of Physalis ixocarpa "shell tomato", this study investigates the impact of weekly foliar spraying of multifloral bee honey at concentrations of 0%, 4%, 4.5% and 5% v/v, during the growing cycle. The objective is to evaluate the post-harvest conservation of the "Señorío 1090" variety of Physalis ixocarpa, grown with agroecological practices in the open field at the Higher Technological Institute of Calkiní during 2019. 90 fruits were collected per treatment and repetition, taking into account the filling of the chalice and the time since its appearance. Subsequently, the harvested fruits were stored at room temperature (25 ± 3°C). At 0, 6, 12, 18 and 24 days after harvest, penetration resistance, pH, titratable acidity, soluble solids content and weight loss were determined. Statistically significant differences were observed in these postharvest physical and chemical attributes due to the foliar application of multifloral bee honey. The treated fruits exhibited greater resistance to penetration, higher citric acid content, lower weight loss, better preservation of soluble solids and a less acidic pH compared to the control group. The results suggest that the application of bee honey may have contributed to the preservation of the quality attributes of Physalis ixocarpa. This conservation potential can probably be attributed to the natural protective film that forms during the growing cycle, derived from the rich nutritional profile of multifloral bee honey, which contains 182 beneficial components. Overall, this study highlights the potential benefits of using bee honey as a foliar spray to improve the postharvest quality of "shell tomato" fruits, thereby improving their marketability and consumer satisfaction.
Keywords: Tomato, honey, quality, postharvest, coatings

INTRODUCTION

Today, there is a strong inclination among the public for naturally crafted and health-conscious edibles, which retain their inherent qualities, extend their shelf life and require subtle processing. These foods are credited as minimally processed due to the actions of sorting, rinsing and trimming, altering the shelf life compared to the original product. Addressing physical, microbiological and physiological degradation, the application of natural coatings or films is crucial to mitigate variations in nutritional and sensory properties, thereby prolonging shelf life (Benito-Bautista et al., 2016). An alternative to mitigate these changes involves the application of barrier/obstacle technology, the use of additives or the synergistic use of various methods, additives and types of packaging, preserving product quality and extending shelf life.

In the constant search to improve agricultural practices and maximize the quality of products, the opportunity arises to explore innovative practices for the post-harvest of crops such as the peel tomato Physalis ixocarpa. In this context, an innovative approach is proposed: spraying aqueous solutions of bee honey throughout the crop production cycle as a possible friendly solution in the agricultural environment.

The peel tomato crop has low productivity of 20 Mg/ha due to climate change. Its adaptation involves a reduction in transpiration and physiological changes, including water relations (Cruz-Álvarez et al., 2012).

Spraying an aqueous solution of multifloral bee honey (Aphis mellifera) emerges as an innovative strategy to optimize the weak consumption existence of peel tomato. Hence the fundamental reason to explore viable and sustainable options, to improve agronomic yields and post-harvest biochemical-physiological processes, avoiding reducing the quality of peel tomatoes.

The purpose of this study is to enhance the production of peel tomato for effective postharvest management. Therefore, the objective of this research was to analyze the effect of weekly spraying of bee honey at doses of 0%, 4%, 4.5%, and 5% v/v during the crop cycle, linked to the postharvest conservation of fruits. Physalis ixocarpa greens, grown with agroecological methods.

MATERIALS AND METHODS

Fruits of green-skinned tomato variety Señorío 1090 from Starseeds International, INC were harvested. The plants were grown with agroecological management with average annual temperature of 26 to 27 °C and rainfall in summer (INEGI, 2010). Random samples of fruits were harvested. Maturity indicators included calyx filling and time elapsed since calyx setting. In the laboratory, calyxes and fruits with physical or pathogenic defects were removed. Subsequently, four treatments were established with three repetitions: T1 4%, T2 4.5%, T3 5% V/V and T0 control 0%. Each replicate consisted of 30 pre-identified fruits placed on rigid plastic trays lined with brown paper. The multifloral bee honey complied with the Mexican standard NMX-F-036-981 Honey de Abeja. Foliar spraying was carried out once a week from transplanting until fruit harvest.

The storage condition was 10° ± 3°C. The evaluations were carried out at 0, 6, 12, 18 and 24 days after harvest. The determined variables included weight loss, evaluated in a sample of 30 fruits per treatment and replication. The loss of resistance to pulp firmness was measured in a sample of three fruits per treatment. This was done individually on opposite sides of the mean diameter using an FVD-30 texture analyzer equipped with a conical probe (Wagner Instruments, CT, USA), and the data were reported in Newton (Ncm^2). Titratable acidity was evaluated based on citric acid (%) using the AOAC (2010) method. Three fruits per treatment were weighed individually (5 g) and homogenized with 50 mL of distilled water. After filtration, a 5 mL aliquot was titrated with 0.1 N NaOH, using 2.5% alcoholic phenolphthalein as an indicator. From the same filtrate, the pH was determined with a Corning pH meter, model 12 NY, USA. The juice of an equal number of fruits per treatment was used to measure the content of total soluble solids according to the AOAC method (2010). A refractometer, Atago model Pr-100 from Guangzhou, China, was used and the results were reported as °Brix. The equipment used was located in the ITESCAM basic sciences laboratory. The experimental design followed a randomized block design. Mean separations were performed using Statgraphics Centurion XVI.I.

RESULTS AND DISCUSSION

LOSS OF PRESSURE RESISTANCE

Loss of resistance to hardness was observed; when analyzing the statistical diagnosis, significant differences were determined between the five storage extension dates evaluated. Treatments with multifloral bee honey exhibited firmer fruits compared to the control, exceeding 44 Ncm^2, highlighting T1-Honey 4.0% V/V with 64 Ncm^2. The firmness in the three treatments and the control decreased after 18 days of harvest, but the fruits treated with honey maintained a lower loss of resistance to firmness compared to the control. The initial firmness of the core at the time of cutting was 42.8 Ncm^2, but it softened to 24.5 Ncm^2 after 24 days of storage Table 1. These results were probably due to the decomposition of the pectic contents that make up the cell wall due to increased enzyme activity, including pectinesterase, polygalacturonase and cellulase (Tucker et al., 1980, Barrett et al., 1998). This change is related to the evolution of the texture, aroma and flavor desired by consumers, inextricably linked to resistance to penetration, a quality parameter that reflects the freshness of the product (Surmacka, 2002) and used as an indicator of fruit maturity (Barrett et al., 1998)

The firmness of the fruit is of great importance, as it serves to measure quality and potential for transportation and storage. As fruit matures, it becomes less resistant to mechanical damage (FAO, 2007). Similar results were reported in resistance to penetration (Benito et al., 2016) using color to identify the physicochemical characteristics that determine the state of maturity of four varieties of husk tomato, García-Sahagún et al (2007) observed values of 44.1 N at harvest and 14.7 N after two weeks of storage at 25°C for other varieties of peel tomato. Comparable values of 7.5 N at harvest and 5.6 N after two weeks of storage have been reported for the cape gooseberry Physalis peruviana L. Statistical analysis revealed significant differences between various sampling dates, the initial value at harvest exceeded 3.80, gradually decreasing to a minimum value of 2.84 after 24 days of postharvest.

ACTIVE ACIDITY OR PH

The pH also showed a similar pattern of evolution in all treatments, with significant differences Table 1. In all cases, there was a pronounced initial decrease until 12 days after cutting. At 18 and 24 days after harvest, no differentiation was found, the 4.5% v/v honey treatment emerged as the most acidic with a pH of 2.60, followed by the control without honey with 2.70 and finally the 4% honey and 5% v/v with pH values of 2.72 and 2.80, forming acidic green tomatoes. The reported pH data are outside the range (3.93 - 4.23) obtained for five autotetraploid and four diploid populations by Ramírez-Godina et al. (2013), who found significant differences in their statistical analysis. This behavior can be attributed to the synthesis and accumulation of organic acids up to the cut-off point and their potential loss through respiration during storage. Likewise, these findings differ from those of Jiménez-Santana et al. (2012), who indicated a range of 3.51 to 4.51 between three tetraploid genotypes and the variety. This trend has been observed in tomato (Juárez López et al., 2009), Physalis peruviana L. (Lanchero et al., 2007), and several tropical fruits, except banana (Torres et al., 2013).

TITRATABLE ACIDITY % CITRIC ACID

Like pH, titratable acidity (TA) (% citric acid) showed a variation during the storage period. Statistical analysis (Table 1) revealed significant differences at various sampling dates. The initial value at the cut-off exceeded 1.35%. A descending pattern in TA trends was observed, possibly attributed to the physiological behavior of the genus Physalis (Cantwell et al., 1992); additionally, the variation could result from treatment effects due to the nutritional content of honey applied weekly. in the plants. or recent genetic practices (Peiris et al., 1997). In the control group of this study, TA gradually decreased to a minimum value of 1.256% after 24 days after harvest. Similarly, the titratable acidity values found (>1.637% citric acid) were statistically the same in the three groups treated with honey, although significant differences emerged compared to the control in the 1.355% harvest, ($p<0.05$). These findings are similar to what was reported by Aguiñaga-Bravo et al., (2020) for green tomato Señorío, with the highest value attributed to the Bokashi-FQ 50% treatment (2.1% TA), they also cite Barone, Caruso, Marra and Sottile (2001) mentioned by González-Mendoza et

Days after harvest	Hardness (N/cm²)	pH	AT (%Citric acid)	SST °brix	Weight (g)
0 days after harvest					
T1-Honey 4.0% V/V	64.0 c	3.84 a	1.681 b	6.62 a	43.87 a
T2-Honey 4.5% V/V	49.3 b	3.81 a	1.637 b	8.05 a	44.27 a
T3-Honey 5.0% V/V	47.1 ab	4.03 b	1.640 b	7.21 b	50.18 b
T0-Without honey	42.8 a	4.03 b	1.355 a	6.06 c	40.09 a
6 days after harvest					
T1-Honey 4.0% V/V	62.0 b	3.62 b	1.695 a	6.38 b	44.30 b
T2-Honey 4.5% V/V	52.7 a	3.27 a	1.735 a	5.61 a	42.65 b
T3-Honey 5.0% V/V	59.6 ab	3.61 b	1.354 a	5.62 ab	50.14 c
T0-Without honey	51.7 a	3.59 b	1.457 a	6.07 ab	37.76 a
12 days after harvest					
T1-Honey 4.0% V/V	50.0 b	3.71 b	1.222 a	6.53 b	38.63 a
T2-Honey 4.5% V/V	59.8 c	3.64 ab	1.240 ab	6.56 b	41.20 a
T3-Honey 5.0% V/V	53.7 bc	3.58 a	1.502 b	6.27 a	49.58 b
T0-Without honey	29.5 a	3.62 ab	1.342 ab	7-04 c	37.06 a
18 days after harvest					
T1- Honey 4.0% V/V	43.6 b	2.93 a	1.534 b	6.54 b	32.53 b
T2- Honey 4.5% V/V	42.7 b	2.86 a	1.434 ab	6.44 b	38.81 b
T3- Honey 5.0% V/V	39.4 ab	2.86 a	1.475 ab	6.34 b	47.12 c
T0-Without honey	34.4 a	2.80 a	1.267 a	4.65 a	20.67 a
24 days after harvest					
T1- Honey 4.0% V/V	43.0 bc	2.72 a	1.533 b	5.26 a	29.58 b
T2- Honey 4.5% V/V	45.3 c	2.61 a	1.820 c	6.41 c	38.30 c
T3-Honey 5.0% V/V	41.5 b	2.84 a	1.608 b	6.10 b	47.08 d
T0- Without Honey	24.5 a	2.70 a	1.256 a	6.37 c	18.68 a

Table 1: Physical-chemical properties of tomato peel linked to foliar spraying of honey

Values with different letters in a column are statistically different (Tukey; $p \leq 0.05$). Titratable acidity (TA), Total soluble solids (TSS), Weight loss (PP).

al. (2011), noting that the fruit of P. ixocarpa is not classified among sweet cultivars (TA < 1%), however, the TA values obtained were greater than 1%. In contrast to this precedent, fresh hydroponic tomatoes show wide TA variations, ranging from 0.19 to 0.45% (Navarro-Lopez et al., 2012; Dobricevic et al., 2007), and in some cases, up to 0.63% (Arias et al., 2000), which contrasts with the AT values reported in this study. However, for industrial purposes, it is recommended that tomatoes have a Titratable Acidity of no more than 0.2% (Hidalgo-González et al., 1998).

In this study, the content of total soluble solids (°Brix) demonstrated significant differences between the three groups treated with honey and the control at various sampling times (Table 1). The lowest value was observed in the control at 4.65 °Brix at 18 days after harvest, followed by the 4% honey treatment with 5.26 °Brix at 24 days, the 4.5% treatment with 5.61 °Brix and at 5% with 5.62 °Brix at 6 days after harvest. These reported data are similar to those found in five autotetraploids and four diploid populations by Ramírez-Godina et al. (2013), indicating a range of 5.95 to 6.63°Brix, with significant differences between populations. Although the content of soluble solids in peel tomatoes was influenced by storage time, comparisons of means revealed non-gradual reductions from cutting to 24 days postharvest, ranging from 8.05 to 2.65 °Brix (Table 1). This behavior can be attributed to an insufficient oxidation of sugars and acids consumed, corresponding to the decrease in the respiratory frequency of this fruit (Peiris et al., 1997), the results were aligned with the natural variability of the species, which presents values ranging from 6.1 to 5.25 within the cut-off interval and after twenty-five days of storage at 20°C (Cruz-Álvarez et al., 2012).

WEIGHTLOSS

The weight loss determined in this study exhibited significant differences due to the three groups treated with honey and the control at the five storage times. The pattern of weight loss showed a continuous decrease until 24 days after harvest (Table 1). The control exhibited the lowest weight at 18.68 g, indicating a greater loss of 53% after 24 days postharvest, followed by the 4% honey treatment with 29.58 g, the 4.5% treatment with 38 .30 g and the 5% treatment with 47.08 g (comparatively 32%, 13%, and 6% reduction). Therefore, the selected shell tomato fruits harvested within the three foliar honey application treatments exhibited a reduced sensitivity to weight loss, attributed to less dehydration due to the protective honey film formed in the organs of the plant, in contrast to the shorter lifespan of the control. This study clearly demonstrated the effectiveness of foliar spraying with multifloral honey bee stored under temperature conditions of 10° ± 3°C in improving the quality, marketability and prolonging the shelf life of husk tomatoes by mitigating the ripening rate. and the use of sugar.

CONCLUSIONS

Tomato fruits subjected to foliar honey spray treatments 4.0, 4.5 and 5.0% v/v exhibited greater firmness compared to the control. This attribute of firmness is suitable for your trade. Each honey treatment exhibited outstanding attributes compared to the control: pH levels were less acidic in the honey-treated fruits, while the control fruits became very acidic at the end of the study; A greater titratable acidity (%) of citric acid was observed in fruits treated with honey compared to the control, despite the fact that their total sugar content was 1.237% citric acid. These findings suggest that fruits not treated with honey demonstrated greater sensitivity to storage conditions. Particularly in this shelf life extension trial, the application of honey prevented weight losses and kept soluble solids relatively stable °Brix, compared to control fruits. Attributes such as firmness, pH, titratable acidity, improved sweetness and reduced weight loss during storage at 10°±3°C determined superior quality, which may influence consumer preference. Consequently, honey-treated peel tomato fruits exhibited greater potential to preserve fruit quality after harvest.

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