Scientia Horticulturae 237 (2018) 51–58

Contents lists available at ScienceDirect

Scientia Horticulturae

journal homepage: www.elsevier.com/locate/scihorti

Postharvest gum Arabic and salicylic acid dipping affect quality and biochemical changes of 'Grand Nain' bananas during shelf life

Ahmad A. Alali[a], Mohamed A. Awad[a,b,*], Adel D. Al-Qurashi[a], Saleh A. Mohamed[c]

[a] Department of Arid land Agriculture, Faculty of Meteorology, Environment and Arid land Agriculture, King Abdulaziz University, P.O. Box 80208, Jeddah, Saudi Arabia
[b] Pomology Department, Faculty of Agriculture, Mansoura University, El-Mansoura, Egypt
[c] Molecular Biology Department, National Research Centre, Cairo, Egypt

ARTICLE INFO

Keywords:
Banana
Gum Arabic
Quality
Salicylic acid
Shelf life
Storage

ABSTRACT

Effects of gum Arabic (GA) (5 and 10%), salicylic acid (SA) (1 and 2 mM) and their combination (10% GA plus 1 mM SA) postharvest dipping on quality and biochemical changes of 'Grand Nain' bananas were studied during shelf life (SL) conditions (20 ± 2 °C, 60–70% RH) for 9 days. All treatments, especially 10% GA plus 1 mM SA, decreased weight loss than control. GA at both rates retained higher peel green color than other treatments during SL. GA at both rates and SA at high rate SA retained higher firmness only after 6 days of SL. Total soluble solids (TSS) concentration increased during SL and was lower at both rates of GA and high rate of SA than control. Titratable acidity (TA) concentration decreased during SL and was higher at both rates of GA, low rate of SA and GA plus SA treatments than control. Peel browning index gradually increased during SL and was lower at high rate of GA than control. Membrane stability index (MSI) decreased during SL and was higher at both rates of GA than other treatments after 6 and 9 days of SL. Total phenols and flavonoids concentrations in peel and pulp and vitamin C in pulp fluctuated during SL and showed no consistent response to applied treatments. As overall, GA retained higher total phenols and flavonoids concentrations, whilst SA showed no clear effects. Free radical scavenging capacity (FRSC) of both peel and pulp increased during SL and was higher at GA and SA treatments than control. The relations of such biochemical changes with α-amylase, xylanase, polygalacturonase, peroxidase and polyphenoloxidase activities were discussed. In conclusion, GA treatment especially at 10% retained quality of 'Grand Nain' bananas during SL and being suggested as natural alternatives to synthetic chemicals.

1. Introduction

Banana (*Musa* spp.) is one of the most commercially important tropical fresh fruit due to its especial flavor and nutritional properties as well as worldwide availability around the year. Bananas of most cultivars such as 'Grand Nain' are harvested at pre-climacteric full mature-hard green stage and thereafter ripening is triggered by exposing to a certain dose and duration of ethylene at about 18 °C and 85% RH in a commercial airtight ground warehouses. However, SL of post-climacteric bananas is relatively short (a few days) and fruit rapidly soften and deteriorate (Duan et al., 2007; Gonge et al., 2013; Suseno et al., 2014; Awad et al., 2017). In this respect, storing ethylene pre-treated bananas at 14 °C with 1% oxygen retained green color and firmness for 28 days (Liu, 1976). However, following storage, these fruit ripened rapidly at 21 °C in air conditions without additional ethylene treatment. In addition, being tropical fruit, bananas are highly sensitive to chilling injuries when exposed to temperature below 13 °C (Wang et al., 2014). In the Kingdom of Saudi Arabia (KSA), huge amount of bananas are spoiled due to prevailing high temperature, humidity, pathogens attack and inappropriate postharvest handling. SL of bananas is coupled with several physico-chemical changes including weight loss, softening, starch hydrolysis, chlorophyll degradation and browning development that increase susceptibility to several physiological and pathological disorders (Maqbool et al., 2011a; Duan et al., 2007; Wang et al., 2014; Al-Qurashi et al., 2017). Application of synthetic chemical preservatives is restricted due to rising consumers concerns on both human health and the environment. Accordingly, natural more save alternative tools to modulate banana ripening and maintain quality during SL are critically required. The use of natural edible coatings such as chitosan, carboxymethyl cellulose and GA is considered a novel approach to delay ripening, reduce water loss and decay, and extend storage and SL of various fruit including banana (Bautista-Banos et al., 2006; Passos et al., 2016; Al-Qurashi et al., 2017). GA is one of the natural biopolymers obtained from stems and branches of Acacia trees (*Acacia* spp.)

* Corresponding author at: Department of Arid land Agriculture, Faculty of Meteorology, Environment and Arid land Agriculture, King Abdulaziz University, P.O. Box 80208, Jeddah, Saudi Arabia.
E-mail address: mawad@mans.edu.eg (M.A. Awad).

https://doi.org/10.1016/j.scienta.2018.03.061
Received 16 December 2017; Received in revised form 27 March 2018; Accepted 28 March 2018

and is consisted of polysaccharide (galactose, rhamnose, arabinose and glucoronic acid) with calcium, magnesium, and potassium ions (Prakash et al., 1990; Motlagh et al., 2006). GA is commercially used as a safe food additive for its film forming, emulsification, and encapsulation characteristics (Anderson and Eastwood, 1989. Motlagh et al., 2006). Maqbool et al. (2011a) found that 10% GA plus 1.0% chitosan as an edible composite coating delayed physico-chemical changes of 'Pisang Berangan' bananas during 28 days of cold storage plus 5 days of SL. GA alone did not show any fungicidal effects while the combination of 0.4% cinnamon oil with 10% GA showed more fungicidal effects, delayed ripening and suggested as a biofungicide for controlling anthracnose in banana and papaya fruit during 28 days of cold storage plus 5 days of SL (Maqbool et al., 2011b). GA coatings effectively maintained antioxidant activity and total phenols of tomatoes (Ali et al., 2013), papayas (Addai et al., 2013), and reduced browning, loss of vitamin C and total phenols of mangos (Khaliqa et al., 2016) during cold storage and SL. SA is a simple phenolic phytohormone having several roles in plant growth and development processes (Raskin, 1992). It is considered as an endogenous signaling molecule involved in plant stress tolerance and inhibition of ethylene biosynthesis and ripening delay of various horticultural commodities (Asghari and Aghdam, 2010). Srivastava and Dwivedi (2000) reported that postharvest dipping in SA at 0.5 or 1 mM decreased respiration rate, ethylene production, cell wall degrading enzymes activities, and delayed ripening of 'Hari chhal' bananas during 8 days of SL. To the best of our knowledge, little available published work on the response of banana fruit to postharvest treatment with GA and SA. Therefore, this study aim to evaluate the response of 'Grand Nain' bananas to postharvest dipping in GA and SA at different concentrations as an attempt to regulate ripening and maintain quality during SL.

2. Materials and methods

2.1. Plant materials and experimental procedure

This experiment was performed on bananas (cv. 'Grand Nain' belongs *to Musa* AAA group) collected from a commercial orchard located in Jizan region (17.4751˚N, 42.7076˚E), KSA. Fruits were harvested, packed as hands in polyethylene film in perforated card box (about 200 kg) and transported from Jizan to Jeddah within 12 h at 15 ˚C. Bananas (at the ripening stage 1, according to a color chart index) were directly pre-treated with ethylene gas (about 0.01% by volume in air) at 18 ˚C and 85% RH for 29 h for ripening induction at a commercial airtight ground warehouses with a great deal of bananas. Such treatment is critical due to ripening induction of 'Grand Nain' banana cultivar. Then, uniform hands (at the ripening stage 2) were randomly selected at the warehouse and rapidly transported to the postharvest laboratory of King AbdulAziz University.

2.2. Preparation of dipping solutions

GA solutions 5 and 10% (w/v) were prepared by dissolving the corresponding weight of GA powder (Elnasr Processing & Food Packaging Factory, Khartoum, Sudan) in distilled water with continuous stirring and heating (40 ˚C) for 60 min by using a hot plate with magnetic stirrer. The pH of final GA solution was adjusted to 5.6 by 1 N NaOH. SA solutions 1 and 2 mM were prepared by dissolving the corresponding weight of SA powder (Fisher Scientific, USA) in distilled water with continuous stirring and heating (40 ˚C) for 5 min by using a hot plate with magnetic stirrer. For the combined treatment, 1 mM SA was incorporated into 10% GA solution and stirred for 15 min.

2.3. Fruit treatments

'Grand Nain' Bananas (at the ripening stage 2) carefully prepared in small uniform hands (about 5 fingers each, free of visual defects and with similar weight and size) were selected. A completely randomized experimental design with three replicates (six hands each) was established. Fruit of each treatment/replicate were soaked either into water (control), 5 or 10% GA, 1 mM or 2 mM SA, or 10% GA plus 1 mM SA combination for 5 min. A surfactant (Tween 20 at 0.5 ml/l) was added to all treatments. Following air draying of about 1 h, all treatments/replicates were weighted and stored at 20 ± 2 ˚C and 60–70% (RH) in perforated cardboard cartons for 9 days. Before applying the treatments (day 0), additional three samples (10 fingers of each) were randomly collected for initial quality and biochemical analyses. After 3, 6, and 9 days of SL, weight loss and peel color stage were recorded for each treatment/replicate. Samples (10 fingers of each) from each treatment/replicate were randomly collected for quality and biochemical analyses after 3, 6 and 9 days of SL. Then, these fruit samples were peeled and the peel tissue was sliced and mixed. Random part of this peel was used for electrolyte leakage measurement and the remaining peel was kept at −80 ˚C for later enzyme, total flavonoids and phenols and antioxidant activity analysis. Pulp firmness was measured in each sample directly following peeling. The pulp tissue was later sliced, mixed and a random portion was used for TSS, TA, pH, and vitamin C determinations.

2.4. Weight loss determination

The total fruit weight loss was calculated on initial weight basis and expressed in percentage.

2.5. Peel color estimation by color chart

Peel color score was recorded independently in 10 randomly selected fingers/replicate with the help of a banana ripening chart (1–7 scale; 1 – green, 2 – green with trace of yellow, 3 – more green than yellow, 4 – more yellow than green, 5 – yellow with trace of green, 6 – full yellow and 7 – yellow with brown spots.

2.6. Peel color measurement by Minolta Chroma meter

Peel color was measured independently in 10 randomly selected fingers (in the middle of each finger) per replicate by a Minolta Chroma Meter CR-410 (Minolta Camera Co. Ltd., Osaka, Japan). The colorimeter was warmed up for 20 min and calibrated on the Hunter lab color space system using a standard white plate (Minolta calibration plate, Y = 84.8, x = 0.3164, y = 0.3237). The values of L*, a* and b* were measured in the middle of each of the ten fruits/sample. The positive value of a* indicates red color, while negative value of a* indicates green color.

2.7. Browning index

Peel browning was assessed independently in 10 randomly selected fingers/replicate by visualizing the total brown area of each fruit surface using following scale: 1 = no browning, 2 = < 20% of the peel surface, 3 = 20–40% of the peel surface, 4 = 40–60% of the peel surface and, 5 = > 60% of the peel surface (Ding and Ling, 2014).

2.8. Firmness, TSS, TA, pH and vitamin C measurements in pulp

Fruit pulp firmness was measured independently in 10 fingers (in the middle of each finger) per replicate by a digital basic force gauge, model BFG 50 N (Mecmesin, Sterling, Virginia, USA) supplemented with a probe of 11 mm diameter and the results were expressed as Newton. A homogeneous sample was prepared from these 10 fingers per replicate for measuring TSS, TA, pH and vitamin C. TSS concentration was measured as a percentage in fruit pulp juice with a digital refractometer (Pocket Refractometer PAL 3, ATAGO, Japan). TA was determined in fruit juice diluted in water at a ratio 1:2 by titrating with 0.1 N sodium hydroxide up to pH 8.2, using automatic titrator (HI