Effect of maleic hydrazide and waxing on ripening and quality of guava (*Psidium guajava* L.) fruit

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ABSTRACT

The effect of postharvest treatment by maleic hydrazide (MH) and waxing on ripening and quality of white and pink guava fruits was evaluated at 20 $\pm$ 1^{O}C and 85-90% relative humidity. MH at 250, 500 and 1000 ppm delayed fruit ripening by 2-6 days in both guava types compared to untreated fruits. The higher the concentration of MH, the more was the delay in fruit ripening. Waxing in addition to MH treatment resulted in 3-4 days more delay in fruit ripening, compared to MH treatment alone. The effect of MH treated and waxing in delaying fruit ripening was manifested in retarded climacteric peak of respiration, delayed peel colour development, reduced total soluble solids accumulation and decreased fruit softening.

INTRODUCTION

Guava (*Psidium guajava* L.) is a popular fruit crop in Sudan. It is grown in almost every State. The fruit is delicate and can store well only for a few days at ambient conditions. Although Sudan has great potential to produce high quality guava and to export it to other countries, its marketability is still limited to local markets. This is due to the delicate nature of the fruit, poor handling practices, and inadequate refrigerated transportation and storage facilities. Therefore, proper handling techniques and control of the ripening process are crucial for the development of a sound guava industry in Sudan.

Maleic hydrazide (1, 2 dihydro 3, 6 pyridazinedione) is known as a growth regulator that inhibits some processes in fruits and vegetables. Several workers reported that MH inhibited sprouting and reduced losses during storage of potato and onion (Fadl *et al.*, 2005). The effect of MH on the ripening process varies with different types of fruits. It delayed fruit ripening in mango (Krishnamurthy and Subramanyam, 1970), papaya (Abu-Goukh and Shattir, 2012) and tomato (Ahmed and Abu-Goukh, 2003). MH applied on sapota fruit (*Achras sapota* L.), however, hastened the ripening process (Lakshiminarayana and Subramanyam, 1967).

Waxing significantly reduces the permeability of fruit skin to gases. The fruit, through respiration, is used to reduce oxygen (O_2) and increase carbon dioxide (CO_2) in its microenvironment. Under such restricted air-exchange, a modified atmospheric condition may be generated and some of the benefits of the modified atmosphere may be achieved (Kader, 2002). Waxing was reported to delay fruit ripening and senescence, reduce water loss, maintain quality and extend the shelf-life of mangoes (Mohamed and Abu-Goukh, 2003), papayas (Abu-Goukh and Shattir, 2012), tomatoes (Ahmed and Abu-Goukh, 2003) and grapefruits (Abu-Goukh and Elshiekh, 2008).

This study was carried out to evaluate the effect of maleic hydrazide and waxing on ripening and quality of white and pink guava types.

MATERIALS AND METHODS

Experimental material

Mature green fruits of white- and pink- fleshed guava fruits were obtained from an orchard at Al-Kadaro, Khartoum North (15^{O} 40' N; 32^{O} 22' E). Fruits were selected for uniformity of size, colour and freedom from blemishes. The fruits were washed, air-dried to remove water from the surface and transported in plastic baskets lined with perforated polyethylene sheets to the laboratory for further treatments.

The fruits of each guava type were distributed among the six treatments in a completely randomized design with four replicates. The treatments were 0, 250, 500 and 1000 ppm MH without waxing and 500 and 1000 ppm with waxing. Maleic hydrazide treatments were applied by dipping the fruits for three minutes in maleic hydrazide (Citrashine N-IMZ "Deco-Pennwalt") solutions of 250, 500 and 1000 ppm and air dried. Food-grade wax (Flucka AG, CH-9470 Buchs) was used for wax treatments. The wax was applied in a thin layer by brushing over the surface of the fruits. Untreated fruits (control) were dipped in distilled water and air-dried. The fruits were packed in carton boxes (43x33x15 cm) and stored at 20 $\pm$ 1^{O}C and 85-90% relative humidity.

Parameters studied

Respiration rate was determined daily during the storage period in 15 fruits in each treatment, using the total absorption method (Mohamed-Nour and Abu-Goukh, 2010) and was expressed in mg CO_2 per kg-hr. Peel colour changes were determined daily on the same 15 fruits used for respiration in each treatment. The colour score used was mature-green (0), trace yellow on skin (1), 20% yellow (2), 40% yellow (3), 60% yellow (4), 80% yellow (5) and 100% yellow (6).

Flesh firmness and total soluble solid (TSS) were determined on three fruits picked randomly from each treatment, other than those used for respiration rate and colour changes, at two-day intervals during the ripening period. Flesh firmness was measured by Magness and Taylor firmness tester (D. Ballauf Meg. Co.), equipped with 8 mm diameter plunger tip. Two readings were taken from opposite sides on each fruit after the peel was removed. Flesh firmness was expressed in kg/cm^2. TSS was determined directly from the fruit juice extracted by pressing the fruit pulp in a garlic press, using a Kruss hand refractometer (Model HRN-32). Two readings were taken from each fruit and the mean values were calculated and corrected according to the refractometer chart.

Statistical analysis

Analysis of variance and Fisher's protected LSD test with a significance level of $P< 0.05$ were performed on the data (Gomez and Gomez, 1984).

RESULTS AND DISCUSSION

Maleic hydrazide (MH) treatment significantly delayed fruit ripening in both guava types, the higher the concentration the more was the delay. Similar results were reported for mango (Krishnamurthy and Subramanyan, 1970), banana (El-Rayah *et al*., 1980), papaya (Abu-Goukh and Shattir, 2012), and tomato (Ahmed and Abu-Goukh, 2003). The wax treatment resulted in more delay in guava fruit ripening. Waxing was reported to delay fruit ripening, reduce water loss and extend shelf-life of mango (Mohamed and Abu-Goukh, 2003), papaya (Abu-Goukh and Shattir, 2012) and tomato (Ahmed and Abu-Goukh, 2003). Waxing significantly altered permeability of fruit skin to gases. The fruit, through respiration, is used to reduce O_2 and to increase CO_2 in its microenvironment. Under such restricted air-exchange, a modified atmospheric condition may be generated and some of the benefits of the modified atmosphere may be achieved (Kader, 2002). The low O_2 and high CO_2 depress the internal ethylene production (Beyer *et al.*, 1984). Ethylene has a stimulation role in the general metabolism of fruit and is required to turn on ripening genes that affect colour changes, TSS accumulation, aroma and degradation of cell walls that result in tissue softening (Baldwin, 2001). This delay in fruit ripening was reflected in changes in respiration rate, peel colour development, flesh firmness and total soluble solid (TSS) in the fruits.

Effect on respiration rate

The respiration curves of both guava types exhibited a typical climacteric pattern. Respiration rate was higher in the pink guava fruits with a climacteric peak of 41.2 mg CO_2/ kg-hr, than in the white ones, with a peak of 34.5 mg CO_2/ kg-hr (Fig. 1). Maleic hydrazide (MH) and wax treatments slightly decreased the climacteric peak in both guava types. Duckworth (1966) reported that MH differs from most growth regulators in depressing the rate of respiration. The untreated fruits reached the climacteric peak after 14 and 16 days in the white and pink guavas, respectively. Fruits treated with MH at 250, 500 and 1000 ppm without waxing reached the climacteric peak two, four and six days later, respectively, compared with the untreated fruits. This is in agreement with previous reports that MH delayed the onset of the climacteric in mango (Krishnamurthy and Subramanyam, 1970), papaya (Abu-Goukh and Shattir, 2012) and tomato (Ahmed and Abu-Goukh, 2003).

Guava fruits treated with MH at 500 and 1000 ppm with waxing reached the climacteric peak seven and ten days later, respectively, compared with the control (Fig. 1). Similar results were reported for mangoes (Mohamed and Abu-Goukh, 2003), papayas (Abu-Goukh and Shattir, 2012) and tomatoes (Ahmed and Abu-Goukh, 2003). Waxing has been shown to influence respiration rate by decreasing oxygen and increasing carbon dioxide content in the internal atmosphere of the fruit (Irving and Warren, 1960).

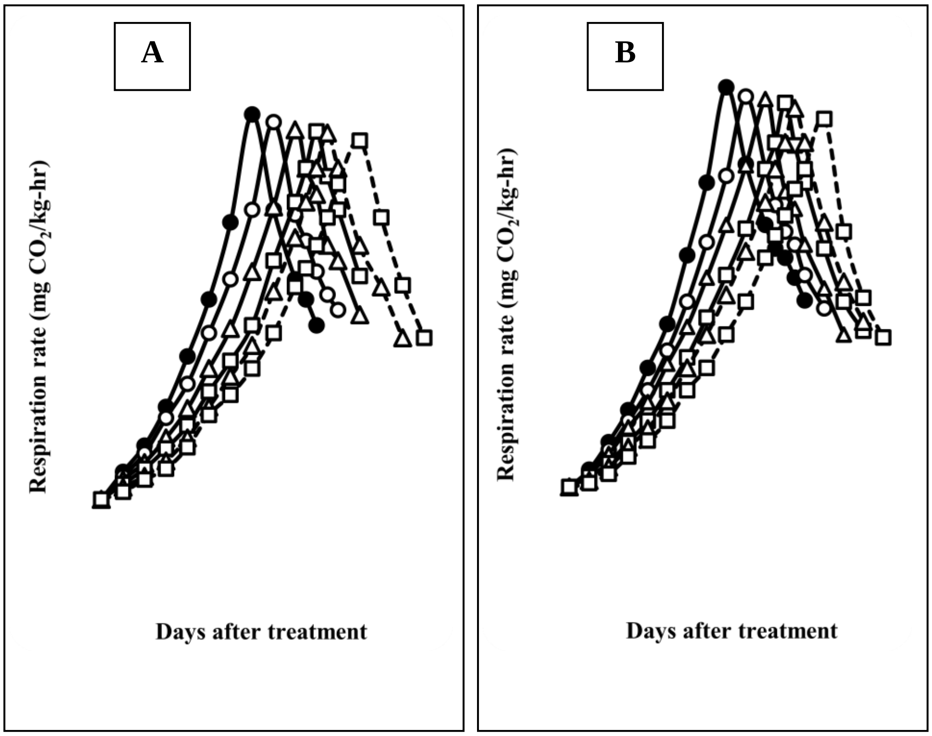

Fig. 1. Respiration rate during ripening of white [A] and pink [B] guava fruits treated with maleic hydrazide at 250 (o), 500 (Δ) and 1000 ppm (□) without waxing (_____) or with waxing (-------), compared with untreated fruits (●) at 20 ±1 ^{O}C and 85-90% relative humidity.

Effect on peel colour

Peel colour score progressively increased during ripening of the two guava types (Fig. 2). The untreated fruits reached the full yellow stage (colour score 6) after 16 days in the white and 18 days in the pink guavas. Maleic hydrazide and wax treatment differentially delayed colour development in peel of both guava types. Fruits treated with MH at 250, 500 and 1000 ppm without waxing reached the full yellow stage (colour score 6) two, four and six days later, respectively, compared with the untreated fruits. While fruits treated with MH at 500 and 1000 ppm with waxing reached the full yellow colour seven and ten days later, compared with the control, respectively (Fig. 2). These results are in line with previous findings that MH treatment delayed peel colour development in mangoes (Mohamed and Abu-Goukh, 2003) and tomatoes (Ahmed and Abu-Goukh, 2003). MH with waxing was more effective in delaying colour development. This agrees with reports that waxing delayed chlorophyll degradation and peel colour development in tomatoes (Ahmed and Abu-Goukh, 2003) and mangoes (Mohamed and Abu-Goukh, 2003).

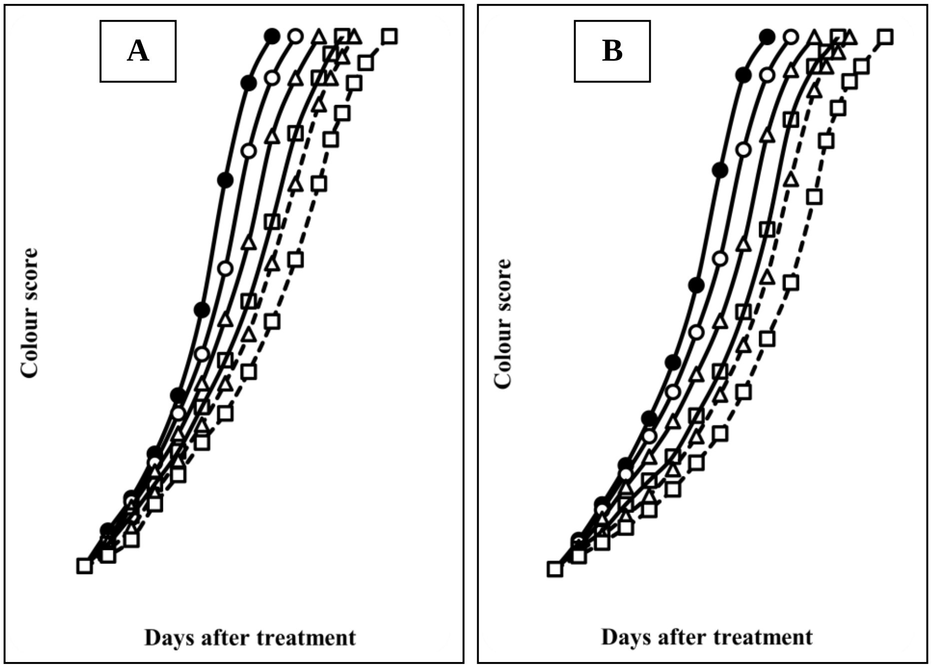

Fig. 2. Peel colour changes during ripening of white [A] and pink [B] guava fruits treated with maleic hydrazide at 250 (o), 500 (Δ) and 1000 ppm (□) without waxing (______) or with waxing (-------), compared with untreated fruits (●) at 20 $\pm 1^{O}$C and 85-90% relative humidity.

Effect on flesh firmness

Fruit flesh firmness of both guava types had shown a continuous decline throughout the ripening period irrespective of the treatment (Fig. 3). MH, with or without waxing, significantly delayed the drop in flesh firmness during the ripening period. The untreated fruits reached the final soft stage (0.13 kg/ cm^2 shear resistance) after 18 days in the white and 20 days in the pink guava types. Fruits treated with MH at 250, 500 and 1000 ppm without waxing reached the final soft stage two, four and six days later, respectively, compared with the untreated fruits in both guava types. This is in agreement with the reports that MH treatment delayed fruit softening during ripening and storage of banana (El-Rayah *et al*., 1980) and papayas (Abu-Goukh and Shattir, 2012). Crandall (1955) failed to influence the ripening of apples treated with MH as foliar spray 1 to 6 weeks before harvest, but the treatment increased flesh firmness of the fruits during storage.

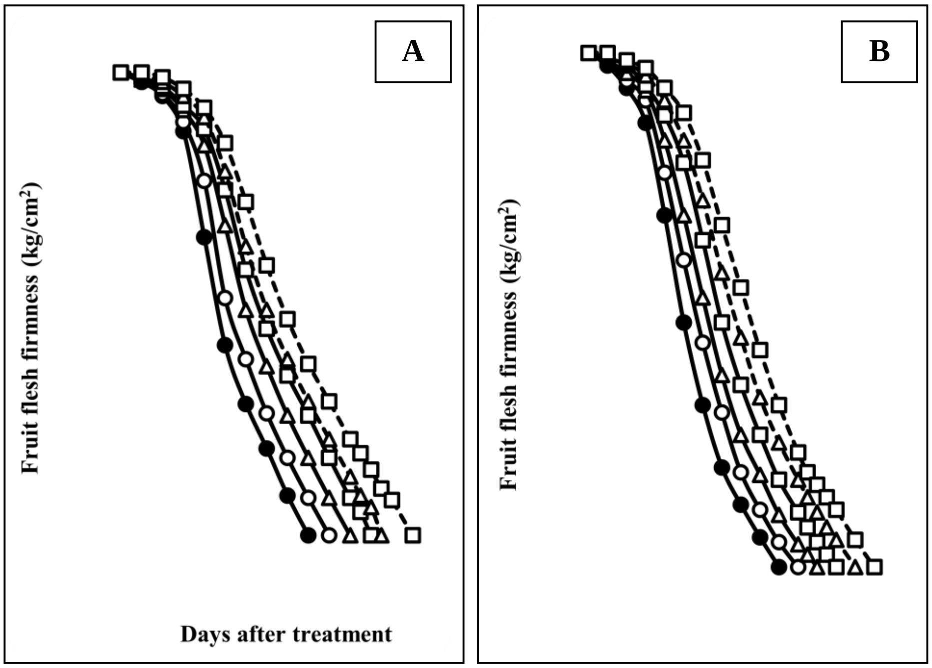

Fig. 3. Fruit flesh firmness changes during ripening of white [A] and pink [B] guava fruits treated with maleic hydrazide at 250 (o), 500 (Δ) and 1000 ppm (□) without waxing (______) or with waxing (-------), compared with untreated fruits (●) at 20 ±1^{O}C and 85-90% relative humidity.

In both guava types, maleic hydrazide with waxing was more effective in delaying fruit softening than MH alone. MH with waxing resulted in three to four days delay in fruit softening, compared with MH treatment alone (Fig. 3). Wax treatment delayed fruit softening in mangoes (Mohamed and Abu-Goukh, 2003), papayas (Abu-Goukh and Shattir, 2012) and tomatoes (Ahmed and Abu-Goukh, 2003). Park *et al.* (1994) reported that surface coating reduced fruit softening and extended the storage life of stored tomato fruit. Fruit softening is characterized by changes in flesh firmness and has long been associated with ripening. These changes in fruit flesh firmness determine the shelf-life and quality of the commodity (Martin-Rodriguez *et al.*, 2002).

Effect on total soluble solids

Total soluble solids (TSS) progressively increased during ripening of white and pink guava fruits (Fig. 4). The maximum TSS values reached by the untreated fruits were 14.3% in the white and 12.4% in the pink guavas. MH treated fruits at 250, 500 and 1000 ppm without waxing reached the maximum TSS value two, four and six days later, compared with the untreated fruits, respectively.

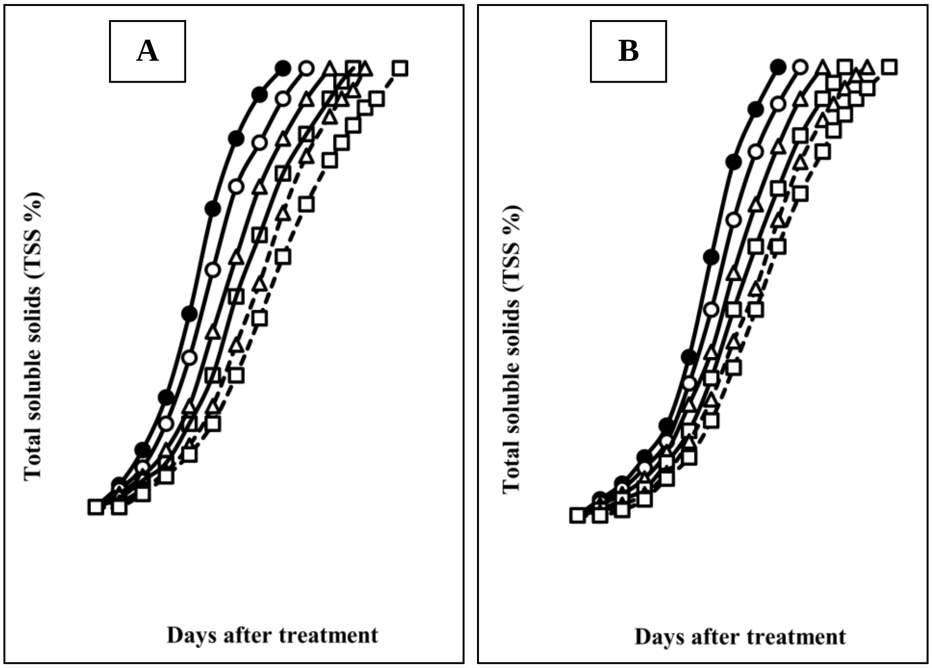

Fig. 4. Total soluble solids (TSS) changes during ripening of white [A] and pink [B] guava fruits treated with maleic hydrazide at 250 (o), 500 (Δ) and 1000 ppm (□) without waxing (______) or with waxing (-------), compared with untreated fruits (●) at 20 $\pm$1^{O}C and 85-90% relative humidity.

MH was reported to decrease TSS accumulation during ripening of banana (El-Rayah *et al*., 1980), papayas (Abu-Goukh and Shattir, 2012) and tomato (Ahmed and Abu-Goukh, 2003). The wax treatment with MH added up to the delay of ripening and accumulation of TSS. It resulted in three to four days delay, compared with MH treatment without waxing. Waxing decreased TSS during ripening and storage of mangoes (Mohamed and Abu-Goukh, 2003), papayas (Abu-Goukh and Shattir, 2012) and tomatoes (Ahmed and Abu-Goukh, 2003).

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تأثير المعاملة بالماليك هيدرزايد والتشميع على إنضاج وجـودة ثمار الجوافة

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الخلاصة

تم تقويم تأثير معاملة ثمار الجوافة البيضـاء والحمراء بعد الحصـاد بالماليك هيدرزايد والتشميع على إنضاج وجودة الثمار عند درجة حرارة 20 ± 1°م ورطوبة نسبية 85-90%. أوضحت النتائج أن معاملة الثمار بالماليك هيدرزايد بتركيز 250 و500 و1000 جزء في المليون أدت إلي تـأخير نضـــج الثمـار بيومين إلي ســـتة أيام في كلا النوعين مقارنة بالثمار غير المعاملة. وكلما زاد تركيز الماليك هيدرزايد كلما تأخر نضـج الثمار. أثبتت الدراســة أن تشـميع الثمار إضـافة لمعاملتها بالماليك هيدرزايد كان له أثراً إضـافياً في تأخير نضج الثمار بثلاثة إلي أربعة أيام مقارنة بالمعاملة بالماليك هيدرزايد فقط. أنعكس تأثير المعاملة بالماليك هيدرزايد والتشميع في تأخير نضج الثمار وتأخير وصول الثمار إلي ذروة التنفس، وتأخير تلون قشرتها، وخفض ليونتها، وتجميع المواد الصلبة الذائبة فيها.