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Research Note

Effects of relative humidity on banana fruit drop

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Abstract

Commercial ripening of banana fruit occurs at high relative humidity (RH), which prevents browning of damaged skin areas. In experiments with ripening at high RH (94 ± 1%) the individual fruit (fingers) of 'Sucrier' (*Musa acuminata*, AA Group) banana exhibited a high rate of drop. The falling off of the fingers is due to rupture of the peel at the pedicel. In contrast, if the fruit was held at low RH (68 ± 3%) finger drop was absent. Water-soluble pectin in the peel at the rupture area was higher at high RH, indicating increased pectin degradation. However, the activities of polygalacturonase (PG) in the peel at the rupture zone were the same in both treatments. The activity of pectinmethylesterase (PME) was only slightly higher prior to rupture in the high RH treatment, whereas, that of pectate lyase (PL) was considerably higher. The lower rate of pectin degradation at low RH may explain, at least partially, why finger drop is inhibited. The decrease in pectin degradation was not accounted for by the measured PG activity, but could be partially accounted for by the measured PME and PL activities.

Keywords: Finger drop; Banana; Pectin hydrolysis; Polygalacturonase; Pectinmethylesterase; Pectase lyase

1. Introduction

Bananas are marketed as bunches of individual fruit (called fingers) that form what is called a hand. If individual fingers are dislodged from the hand, the market value of the hands decreases considerably. Such finger drop is typical for some banana cultivars (Imsabai et al., 2005). Finger drop is defined as a physiological weakening at the pedicel, which causes the individual fruit of a hand to separate easily (Baldry et al., 1981). Banana fruit are usually ripened at a relative humidity (RH) of more than 90%, which will prevent early browning of the skin. These conditions are conducive to finger drop. Lower RH during banana ripening reduced drop (Semple and Thompson, 1988; Prayurawong, 1999).

We previously confirmed that finger drop is caused by breakage of the peel at the rupture zone (Imsabai et al., 2005). The breakage might be due to a number of factors such as fiber content, cell wall structure, and degradation of cell wall macromolecules. The cell wall connection between the cells might be weakened by degradation of pectic components in the primary cell walls and the middle lamella. Using two cultivars held at high RH, Imsabai et al. (2005) found a correlation of finger drop with the activity (in the peel at the rupture zone) of pectate lyase (PL). No correlation was found between finger drop and activities of polygalacturonase (PG) and pectinmethylesterase (PME).

In the present study, we used 'Sucrier' banana which shows considerable finger drop if ripened at high RH. We ripened the fruit at high and low RH, resulting in high and zero finger drop, respectively. We measured the water content of the peel, the degree of pectin hydrolysis and the activities of the above-mentioned cell wall hydrolases.

2. Materials and methods

'Sucrier' (*Musa acuminata*, AA Group) bananas, locally known as 'Kluai Khai', were harvested at commercial maturity in the morning. The fruit were placed in corrugated cardboard boxes and transported by refrigerated truck (25 °C) to the laboratory, where they arrived within 3 h of harvest. Hands were selected for uniformity of size and colour and cleaned in a solution of 200 mg/L chlorine (Clorox®). They were dipped for 2 min in 500 mg/L ethephon for uniform ripening and then dried at ambient temperature (29–30 °C). The fruit were ripened (at 25 °C and 85–90% RH) until reaching the colour index 3–4 (Lizada et al., 1990) and were then used for further experimentation.

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Three hands of banana were placed in a plastic basket. The low RH treatment was maintained by inclusion of silica gel, which was changed every 4 h. The high RH treatment fruit were covered with unsealed polyethylene (PE) bags. Data loggers were placed inside each PE bag to monitor both RH and temperature during the 9 days of the experiments. The two treatments consisted of three replications (plastic bags, with three hands each). Each replication consisted of about 50 fruit.

The method for measuring finger drop was modified from Semple and Thompson (1988). A hand of banana was raised horizontally to 15 cm above the table for 30 s. The number of dislodged fingers was expressed as a percentage of total number of fingers on the hand.

Measurement of resistance to finger drop was as described by Imsabai et al. (2005). Briefly, banana fruit was inserted in a hole and held by a clip, connected to a spring weight. As the pedicel of banana was pulled, the piston of the spring weight and a marker moved together. The marker on the spring weight stopped when the pedicel dislodged. The force at moment of rupture was indicated on the marker. The resistance to finger drop was expressed in kg. The experiments used 15 fingers per treatment. The hands used originated from different replications (plastic bags).

Firmness at the middle of the fruit was determined twice in each fruit (at opposite sides) using a firmness tester with a cylindrical plunger 0.5 cm in diameter. The plunger was inserted to depth of 0.5 cm. The necessary force was recorded in newtons (N). The test was done using 15 fruit, originating from 3 replicate plastic bags.

To measure water content, the peel at the rupture area was collected, weighed and oven-dried at 60 °C for at least 5 days, until the weight did not further change. The water content was calculated as a percentage of total weight. The measurement was carried out with nine hands in each treatment.

The extraction method for various pectin fractions used was as described in Robertson (1979) and the method for uronic acid followed Blumenkrantz and Asboe-Hansen (1973). Extraction method for PG, PME was described in Abu-Goukh and Bashir (2003) and assay methods were described in Yoshida et al. (1984), Hagerman and Austin (1986), respectively. For PL the extraction method was described by Payasi and Sanwal (2003). Protein content in the enzyme extracts was estimated using the Bradford (1976) method. Specific activity of the enzyme was expressed as units per mg protein. Measurements were carried out using three biological replications, based on the three plastic bags per treatment.

All data were treated by analysis with the *t*-test between means determined at the 5% level. The experiment was once repeated at a later date, confirming the earlier results. The data of one experiment are described here.

3. Results

3.1. Finger drop, firmness, peel water content

The temperature and RH were recorded every 15 min, in six bags per treatment. The average RH (and S.D.) in the low and high RH treatments were 68 ± 3% and 94 ± 1%, respectively. Temperatures varied between 25 and 26 °C and were the same in the two treatments (results not shown).

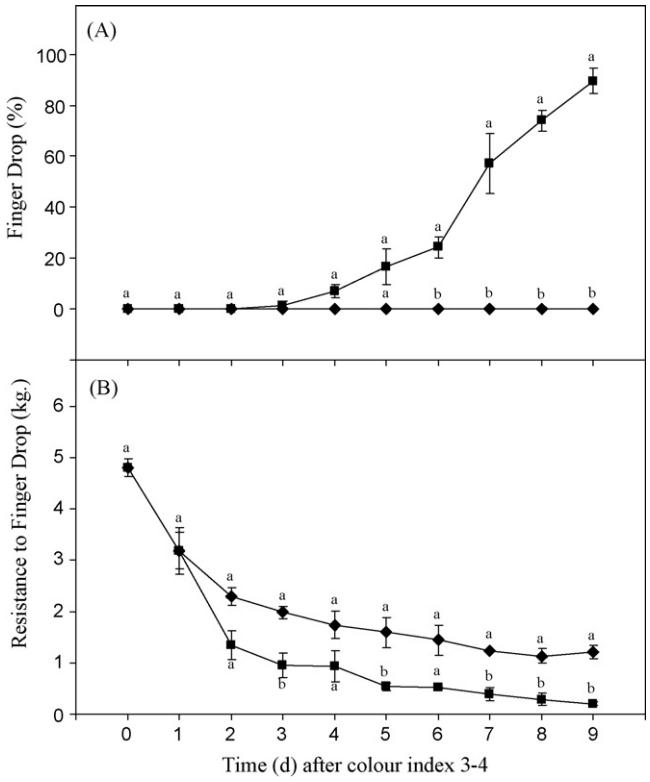

Fig. 1. Finger drop (A) and resistance to finger drop (B) in ripening 'Sucrier' bananas held at low (♦) or high (■) RH. Comparisons are made between means on the same day. If followed by different letters, means are significantly different at $P \leq 0.05$. Vertical bars indicate S.D. When no bar is shown S.D. was smaller than the symbol.

On day 0 of the experiments, the fruit had a colour stage 3 or 4, that is, the fruit was about as yellow as green (stage 3) or slightly more yellow than green (stage 4). Finger drop of fruit ripened at high RH occurred from day 4 and increased to 90% within the next few days (Fig. 1A). Bananas held at low RH did not show any finger drop (Fig. 1A).

The resistance to finger drop of fruit held at high RH decreased more rapidly than that of bananas at low RH. The difference was different at the 5% level from day 2. The difference remained throughout the experiment (Fig. 1B). Firmness was measured in the middle of the fruit, with the peel. It decreased more rapidly at high RH than at low RH. A difference was observed from day 2 (Fig. 2A). The water content of the peel at the rupture area (Fig. 2B) was higher in fruit held at high RH. The difference was statistically significant by day 5 to day 9.

3.2. Pectin fractions in the peel at the rupture area

Three pectin fractions were measured in the peel at the rupture area. Water-soluble pectin, a measure of pectin degradation, increased to a maximum on day 4 and 5 and declined steadily thereafter. The water-soluble pectin fraction of fruit ripened at high RH was higher from day 3 and stayed higher until the end