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Insight into the finger drop of banana

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ABSTRACT: Banana is one of the leading crops in world fruit production and world trade. It is grown globally in tropical and subtropical regions. Bananas are widely consumed and are considered healthy and required for a balanced diet. The post-harvest disorder of finger drop is one of the major threats to the banana fruit industry as it causes economic losses worldwide. Finger drop is a common disorder that is associated with causes that include environmental and genetic factors. This review not only describes the causes of finger drop in bananas which lead to post-harvest losses, but also discusses the biochemical processes involved and practical management techniques that can be used to prevent it and retain premium quality for higher market value.

KEYWORDS: banana, ripening, finger drop disorder, post-harvest loss

INTRODUCTION

Bananas can be served both for fresh fruit consumption and as a staple food that can be cooked and prepared in other ways. Bananas are one of the leading crops in world fruit production and trade, and rank as the leading crop in volume terms among tropical fruits. They are expected to account for approximately 53 percent of the total global tropical fruit production in 2028 [1]. The development of an individual fruit of banana occurs as a 'finger', an individual banana attached to the crown. Fingers grow in groups known as hands and there may be as many as twenty fingers depending on the genetic basis of the cultivar or selection and on selected cultivation practices. Finger drop is a physiological disorder of both bananas and plantains. It exhibits the dislodgement of individual fingers from the cluster or hand upon ripening (Fig. 1). Finger drop is an abnormal non-pathological change in plant tissues expressed in response to the interaction between genotype and environment. It has an important role in banana quality affecting the attractiveness of the cluster and sale value. Finger drop develops in response to an adverse post-harvest environment, especially relative humidity [2]. This minireview discusses briefly the finger drop phenomenon in banana fruit and makes recommendations as to how to mitigate the disorder.

FINGER DROP

Banana and plantain are often marketed as groups of fingers attached together to form a hand, or a cluster, typically having 4–6 fingers on the market shelf. If individual fingers are dislodged from the hand, they have a lower market value with reduced shelf life, and do not present an attractive appearance for customers. This phenomenon is differentially called finger drop [3], pedicel strength, or weak neck [4–6], but finger drop is more commonly used in scientific reports [6–8]. Dislodged fingers do not have a low eating quality, but they just cannot be kept long, especially at ambient room temperature [2]. Furthermore, the rupture area of dislodged fingers becomes wounded and prone to disease infection, resulting in fruit decay and post-harvest loss.

Symptom development

Finger drop is a physiological disorder that occurs as a result of the softening and weakening of the pedicel which causes individual fruit of a hand to separate or dislodge very easily from the crown [7, 9, 10]. Finger drop is caused by breakage of the peel at the rupture zone which does not have an abscission zone like typical leaf or fruit drop [11]. The cell wall connection between the cells, however, might be weakened by the degradation of pectic components in the primary cell walls and the middle lamella in the rupture zone [12].

Causal factors

There are many factors controlling finger drop including genetics and environment. Individual factors are more or less decisive to cause finger drop. Some of them interact and become more severe in finger drop development than when occurring alone.

Clonal difference

Susceptibility to finger drop varies among banana cultivars and it was first reported in the triploid 'Cavendish' (AAA) [13] and in banana tetraploids [14]. However, several reports suggest that besides ploidy level, the

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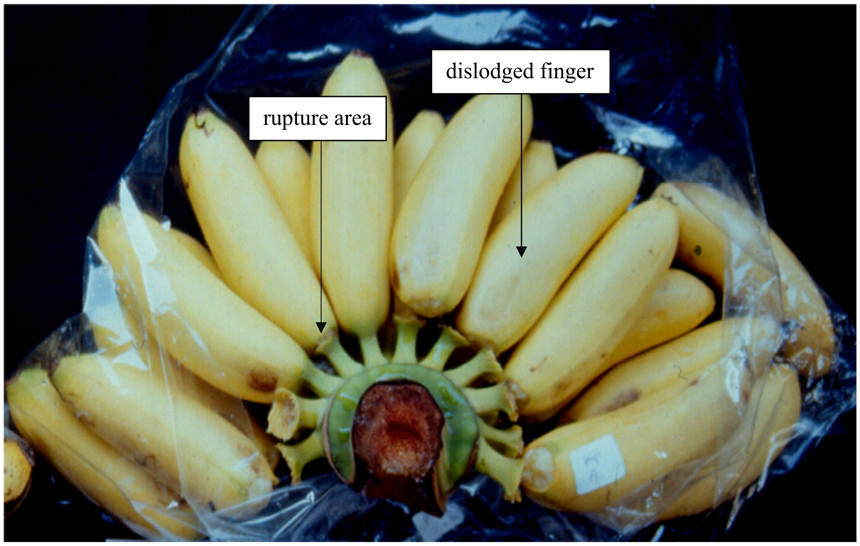

Fig. 1 Finger drop of 'Sucrier' banana (*Musa acuminata*, AA Group) held continuously at 90% RH, showing the rupture area and fruit dislodged (arrows). (Photo credit: © Ketsa S.)

type of genome also influences susceptibility. Bananas that have the B genome are less prone to fruit drop when compared to bananas with the A genome [4]. This indicates that the alleles of resistance to finger drop may be associated with the *Musa balbisiana* species. The diploid *M. balbisiana* (BB) and triploids with the B genome (ABB and AAB) showed higher resistance to fruit drop when compared to diploids and triploids of *Musa acuminata* (AA and AAA) and tetraploids of this same group [7, 15, 16]. Tetraploid hybrids are more susceptible to finger drop when compared to triploid cultivars [10, 14, 17]. Finger drop also occurs in 'Kluai Khai' (known internationally as 'Sucier'), which is diploid [18]. Some cultivars in the same triploid group with different genotypes can exhibit a difference in finger drop display. For example, 'Kluai Hom Thong' (*M. acuminata*, AAA Group) exhibited 100% finger drop when they were fully ripe while 'Kluai Namwa' (*Musa* × *paradisiacal*, ABB Group) did not show finger drop at all when fully ripened under high relative humidity [19]. At ambient temperature, finger drop of 'Kluai Namwa' banana was observed on the seventh day after harvest and the drop increased continuously with more than 50% of the fingers affected on the ninth day [20]. Susceptibility also varies widely among cultivars within the same genome. For example, 'Valery' (*M. acuminata*, AAA Group, Cavendish) is considerably more prone to finger drop than 'Gros Michel' (*M. acuminata*, AAA Group, non-Cavendish) [10].

Relative humidity (RH)

High RH is the most important factor that has been reported to induce banana finger drop [10, 18, 21]. 'Sucrier' (*M. acuminata*, AA Group) banana, exhibited a high rate of individual fruit drop when ripened at high RH (94 ± 1%). In contrast, if the fruit was held at low RH (68 ± 3%), finger drop was absent. The detachment of the fingers is due to a rupture of the peel at the pedicel. The resistance to finger drop of fruit held at high RH decreased more rapidly than that in bananas that were held at low RH [21]. Softening of fruit during ripening may be associated with the water relations of the cell and the composition of the cell walls.

Temperature

Lower ripening temperatures resulted in higher values of the force required to break the peel of the pedicel in freshly ripened fruit and this difference was maintained over a post-harvest shelf life of 5 days. Finger drop occurred with fruit ripened at 25 °C but not with fruit ripened at 20 °C [10]. Similarly, it was found that banana (*M. acuminata*, AA Group, 'Sucrier') fruit held at 22 °C exhibited later finger drop than those held at either 25 or 28 °C [18]. However, ripening at very high temperatures (40 °C) did not result in the development of finger drop, but fruit ripened at this temperature was unmarketable [7]. Finger drop in bananas of tetraploid clones, which are highly susceptible to its development, could be minimized by ripening at temperatures about 2 °C lower than those optimal for 'Valery', a major commercial triploid cultivar [10].

Ethylene

Bananas are a climacteric fruit [22] and have an autocatalytic ethylene-producing system [23]. Clones with a low susceptibility to finger drop were generally also characterized by a long pre-climacteric period [10]. The compound α-aminoisobutyric acid (AIB) is an ethylene biosynthesis inhibitor that inhibits ethylene synthesis by inhibiting aminocyclopropane-1-carboxylic acid oxidase (ACO) [24], while 1-methylcyclopropene (1-MCP) is an inhibitor of ethylene action [25]. Both AIB and 1-MCP treatment significantly reduced finger drop of bananas [5]. This indicates that ethylene is likely to be involved in the development of finger drop. Ethylene effects on the development of finger drop of bananas (*Musa*, AAA Group, Cavendish subgroup) also varied depending on temperature. At 30 °C there was generally no significant effect on finger drop or pedicel strength. At 20 °C there was a general indication that fruit exposed to ethylene for two days or more had weaker pedicels than fruit exposed to ethylene for only one day. In some cases the weakening of the pedicel was initiated regardless of ethylene exposure, which indicated that this effect did not fully account for the increased level of finger drop when bananas were subject to prolonged exposure to ethylene [7].

Other factors

No evidence was found for a decisive role in this rupture of the pedicel with any of the following factors: fruit weight, peel thickness, and water content of the peel at the rupture area [12]. Water loss and water content in the peel do not seem to have any effect on this process. Peel at the pedicel adjacent to the rupture areas of bananas held under high RH contained higher fiber content than that of the peel at the same area held under low RH [26]. In addition, more mature hands were more prone to finger drop [27].

Biochemical involvement

The banana rupture area does not contain an abscission zone, which means that the rupture must be due to weakening of the peel at the pedicel [7, 10, 12]. One of the reasons for such weakening might be pectin degradation. There was a good correlation between finger drop and a prior increase in two pectin fractions in 'Kluai Hom Thong' (*M. acuminata*, AAA Group) fruit, which had massive finger drop, and 'Kluai Namwa' (*M.* × *paradisiaca*, ABB Group) fruit with no finger drop [12]. The lower rate of pectin degradation at low RH may explain, at least partially, why finger drop is inhibited [20]. This indicated that high RH is likely to play an important role in inducing cell wall hydrolase enzymes responsible for the solubilization of cell walls in the rupture area involved in banana finger drop. Water-soluble pectin in the rupture area, in bananas held under high RH, was significantly higher than in fruit held at low RH. Pectin bound with calcium (CDTA soluble pectin) was lower at high RH. In contrast, little change was found in pectin that had not been degraded (alkaline-soluble pectin) [12, 28, 29]. Based on studies of polygalacturonase (PG), pectin methylesterase (PME), and pectate lyase (PL) activities in the peel at the rupture area of bananas at low RH and high RH, it was concluded that involvement of these enzymes in finger drop varied depending on the cultivar and on genetic background [3, 12, 28, 29]. Taken together it can be concluded that finger drop in bananas is related to pectin hydrolysis and was correlated with PG, PME, or PL activities in the pedicel at the rupture area, depending on cultivar.

Mitigation management

Many reports have outlined proposals to solve the finger drop problem through by both pre- and post-harvest applications of various means for the control of this disorder.

Clonal selection

The genetic background of bananas plays an important role in susceptibility to finger drop. The level of susceptibility or resistance to finger drop is different among the different groups of *Musa* spp. which include A and B genomes, and diploid, triploid, and tetratploid types. *Musa* sp. group with B genomes is more resistant to finger drop than in those with A genomes. The diploid group of *Musa* sp. is more resistant than either triploids or tetraploids, while triploids are more resistant than tetraploids [4, 12, 17]. The genome composition of banana cultivars grown in Southeast Asia has been reported previously [30]. Therefore, information on banana genomes can be used for making planting decisions by growers or for use in breeding programs for the development of new cultivars which have greater resistance to finger drop. Besides developing resistance to finger drop, however, clonal selection must be taken into consideration involving eating quality and marketing preferences.

Environments

High RH in the ripening chamber is required to promote the development of proper yellow peel color during the ripening of bananas [31]. Besides ensuring proper color development, RH is important in controlling the incidence of finger drop [17, 26]. RH must be reduced to approximately 80% from 90% once the fruit has reached the turning color stage [32]. Finger drop in bananas of tetraploid clones, which are highly susceptible to the development of finger drop, could be minimized by ripening at temperatures about 2 °C lower than those optimal for 'Valery', a major commercial triploid cultivar [10]. This is also true for 'Sucruer' [17].

Chemicals

Calcium chloride as a pre-harvest spray delayed finger drop and fruit yellowing in 'Latundan' banana which is very susceptible to finger drop [33]. Applications of 200 µl/l gibberellic acid (GA), 4% calcium chloride, or 60% ethanol (v/v) at the pedicel-end portion of banana fruit after harvest were effective postharvest treatments against the disorder, with no finger drop occurrence for 15 days at 22–25 °C storage [3].

Application of low concentrations of ethylene, probably about 1 µl/l, could also reduce finger drop [10], similar to the inhibition of senescent spotting in 'Valery' by treatment with exogenous ethylene [34]. On comparing AIB with 1-MCP under cold (7 °C) and ambient (27 ± 2 °C) storage conditions, postharvest dipping of AIB showed better results with reduced finger drop than 1-MCP fumigation [5].

CONCLUSION

Finger drop mainly occurs due to high RH conditions after harvest. Comprehensive knowledge about the causes, biochemical processes involved and mitigation of finger drop in banana fruit is very important for the effective control of this disorder. Improved knowledge about the biotechnological processes involved with finger drop, and effective breeding and selection strategies, are likely to provide mitigation options for this disorder. Their implementation does not always require complex technical interventions but they do require a basic comprehensive knowledge about the cause.

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