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Finger drop: A major concern for storability, post harvest quality and marketing of banana

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Abstract
Physico-chemical changes that occur during ripening affect the post harvest quality and shelf life of banana fruits. Finger drop is a major post harvest physiological disorder that deteriorates the quality of banana particularly in cultivars having genome "A". Enzyme activity was found responsible for this disorder. Various practices including application of chemicals and growth regulators have been adopted to check this disorder and to improve quality of banana during storage. Research works pertaining to the cause, symptoms and prescribed solutions have been reviewed in this paper.

Keywords: Finger drop, enzyme activity, shelf life, post harvest quality, growth regulators

Introduction
Finger drop has been defined as the physiological softening and weakening which leads to separation of individual fruits in a hand from its crown (Baldry *et al*., 1981) [1]. The individual detachment of the fruit coincides with ripening, resulting in high postharvest perishability. Finger drop varies from genome to genome and it is observed in diploid cultivars (Prayurawong, 1999) [16], triploid Cavendish AAA Group (Semple and Thompson, 1988) [20], and in tetraploid cultivars (Marriott, 1980) [9]. Tetraploid cultivars were found to be more sensitive than others (Marriott, 1983) [10]. It is observed that *Musa balbisiana* i.e. genome B is more tolerant to this disorder than *M. acuminata* i.e. genome A (Imsabai; Ketsa, 2007). Banana (*Musa paradisica* Linn.) being world's largest monocotyledonous, monoecious, monocarpic herbaceous perennial plant, belongs to section Eumusa and family Musaceae of the order Scitamineae. It is referred as 'Kalpataru', mainly herb with all imaginable uses because of its importance among all classes of people. But its marketing and storage is always a headache for banana growers and traders. Due to high perishability, particularly during ripening of fruits, changes in various biochemical components like carbohydrate composition, cell wall adhesion, formation of volatile compounds and chlorophyll degradation take place which ultimately lead to weakening of fingers and detachment from its stalk. Fiber content, structure of the cell wall and degradation of the macromolecular constituents of the cell wall are the factors that lead to rupture of pedicel (Pereira *et al*., 2015; Castricini *et al*., 2015) [13, 3]. It was also observed that dropping may occur due to the faster degradation in amount of structural components of cell walls from parenchyma cells (Mbeguie *et al*., 2009) [8]. Various growth regulators and chemicals were tested and recommended to overcome this problem.

Importance of finger drop
Banana clusters are generally marketed by 5 or 6 fingers attached together. Finger drop is a process that occurs during fruit maturation or ripening, where a finger breaks off from the cluster crown. Hands of banana with fingers missing are never accepted by consumers. Hence this reduces the market value (Semple and Thompson, 1988) [20] and increases the potential risk of pathogen contaminations.

Stimulation of finger drop
It was observed that post harvest environmental conditions like high relative humidity and high ripening temperature primarily stimulate banana finger drop (Semple and Thompson, 1988) [20]. Ethylene also plays a major role in this (Paull, 1996) [12]. In addition, more mature hands are apparently more prone to finger drop (Paull, 1996) [12]. However, water content

in the peel does not seem to be have any effect in this process. Finger drop seems to be due to weakening of peel at the pedicel (New and Marriott, 1983; Semple and Thompson, 1988) [10, 20]. Occurrence of banana peel softening during ripening might be due to depolymerization of pectic substances in the primary cell wall and the middle lamella (Seymour, 1993) [21] and is believed to have involvement of a number of cell wall hydrolases. Weak neck that ultimately leads to finger drop may have three possible causes: genetics, nutrition and post-harvest conditions (Putra *et al*., 2010) [17].

Etiology of finger drop

Tissue abscission is not the cause of finger drop. The detachment of peel at the junction of fruit and the hand causes this kind of rupture. Evidences noted regarding this rupture proved that fruit weight, thickness or peel water content at the rupture portion didn't affect, but a positive correlation was found with the activity of enzyme in the peel at rupture area (Imsabai *et al*., 2006) [5]. Physiologically, peel and pulp softening leads to fruit ripening. Due to depolymerisation of pectic substances, the change occurs in pectic components of the primary cell wall and middle lamellae. The breakdown results in increase of pectin methyl esterase activity. (New and Marriott, 1983; Saengpook *et al*., 2007) [10, 19]

This phenomenon is associated with weakening of the pedicel and absence of a preferential abscission zone, suggesting a peel weakening. This break up occurs at the pedicel (lignified tissue - pulp/non-lignified tissue) function zone. No evidence was found for a decisive role in this rupture of any of the factors such as fruit weight and thickness and water content of peel at the rupture area. A positive correlation was found with the activity of enzymes in the peel at the rupture area. Physiologically, fruit ripening occurs due to peel and pulp softening. Currently, this softening is linked to a change in the pectic components of the primary cell wall and middle lamellae due to a depolymerization of the pectic substances. Peel of bananas having finger drop symptoms contain more water soluble pectin at the rupture area. Imsabai *et al* (2006) [5] showed a lower content of CDTA soluble pectin and insoluble pectin in those sensitive variety, suggesting a pectin breakdown and a pectin degradation. This breakdown leads to an increase in pectate lyase and pectin methyl esterase activity that results in expression of major cell wall modifying gene and ethylene biosynthesizing gene occurring in the finger drop area.

Physiological and bio-chemical changes during Ripening

On ripening of fruit, there is an increase in the rate of respiration and so they need supply of ethylene for complete maturation. During ripening of banana, the color and taste of pulp change. It becomes more softened and there is more production of its own ethylene causing conversion of starch into sugar due to which the color of peel gets changed. An introspection to research work revealed that there were some changes in the cell wall during ripening of fruit (Smith *et al.*, 1989) [22]. Due to textural changes in pectin, softening and maturation occurs in some fruits. During ripening of fruits, these are converted into sugars and acids (Pilinik *et al*, 1970). As It has been classified under climacteric fruit on the basis of the pattern of respiration and ethylene production during maturation and ripening, high ethylene production commences at the onset of respiratory climacteric period. Unlike other climacteric fruits, banana fruits exhibit a sharp rise and fall in the rate of ethylene production during early climacteric rise of respiration. Fungal fruit infection may occur during post harvest storage and marketing conditions, as fruits contain high level of sugar and nutrient elements. Low pH value makes them susceptible to fungal decay.

Effect of finger drop on shelf life

Due to its tendency towards fast ripening and textural break down, banana is difficult to keep well for longer period of time. It is highly perishable with post-harvest losses of 30-40% between harvesting and consumption. The fruits of tissue cultured banana cv. Grand Naine are having very short storage life as compared to other cultivars. Finger drop has been a major problem in case of this variety which occurs during ripening. Post-harvest environmental conditions directly govern this physiological disorder intensity. High relative humidity stimulates finger drop. However, water content in the peel has seem to have no effect in this process. High ripening temperature and ethylene promotes weak neck. Physiological age of hand influences the sensitivity: more mature they are, more sensitive they are.

Occurrence of finger drop during ripening decreases sugar content, acid content, carotenoid, phenolic substances, water content, protein, vitamins, fiber and fat content. Several changes among these lead to deterioration in edible quality and firmness which again cause the attack of pathogens making it completely inconsumable and unmarketable. Quick blackening or rotting occurs during storage of banana which also decreases its shelf life.

Pathak and Sanwal (1999) studied the regulation of ripening of banana fruits by chemicals. As per his observation pulp to peel ratio of banana fruits were found to be increased during ripening. Pulp to peel ratio is related to the change in sugar concentration in the tissues. It was observed that concentration of sugar increased more rapidly in pulp as compared to peel and thus change in osmotic pressure occurs which lead to withdrawal of water from peel and pulp to peel ratio increased. Burden *et al* (1995) [2] found that the peel contained 85-90% water and 28-60 mg DM/cm^2 surface area. The ratio of fruit pulp to peel differed between varieties (1.18-2.28). Moisture content of peel was found to be decreased whereas that of pulp was found to be increased. This occured because the peel lost water both to the atmosphere and to the pulp. An increased pulp to peel ratio was observed by Tripathi *et al* (1981). Loesecke (1950) [23, 6] reported that increase in pulp weight was due to an increase in water content. The water obtained from peel and also from stalk causes weight loss of peel. According to Palmer (1971) [11] there was an increase in osmotic pressure of peel during ripening. An initial pressure 6 atm was found in case of pulp which became 25-27 atm at final stage. Selection of appropriate pre and post harvest management practices to the type of crop can minimize the losses and detrimental effects during storage.

Combating finger drop and post harvest quality degradation

Number of workers made attempts to solve finger drop problem by both pre and post harvest applications of balanced nutrition during fruiting stage. Numerous scientists also tried to enhance the storage life of banana using different substances to control environmental condition at the pre and post harvest stages. Pre harvest applications of calcium, potassium and various micronutrients helps in increasing quality and shelf life of fruits. Esguerra *et al* (2009) [4] applied calcium chloride as pre harvest spray and found delay in finger drop and fruit yellowing in 'Latundan' variety which is very susceptible to finger drop disorder. It is proved that use

of film packaging, packing in polythene bags or news paper, $KMnO_4$ and wax emulsion coating of fruits during post harvest storage stages can delay onset of ripening thereby extending its storage life (Philippe *et al*., 2010). Post-harvest applications of waxol, GA_3 and Kinetin helped banana in maintaining green color and firmness for longer period at ambient temperature (Raghava Rao and Chundawat, 1986) [18]. However, most of the synthetic chemicals being used for crop protection are reported to pose a serious threat to human health and have residual effect, besides being costly, therefore, all these factors have lead to research for safer and more competitive alternatives to extend shelf life and to control finger drop problem.

Many research works have been carried out on edible coatings and films are done to diminish crop losses and maintain the quality of fruit. Chitosan based edible coating is found useful to improve the quality and extend shelf life of fruits since it is able to form an ideal coating on fruits surface to delay the ripening. Besides this, it is regarded as a safe material. As compared with other polysaccharides, chitosan has various advantages including biocompatibility, biodegradability, no toxicity and it has antimicrobial properties. Gibberellins and benzyl adenines are group of growth substances known to retard ripening and senescence of fruits. Garlic extracts are having anti-microbial particularly anti-fungal property which prevent fruits from fungal destruction and hence improve shelf life. Application of 150 ppm Gibberelic acid leads to long shelf life of banana as reported by Mary and Sathiamoorthy (2003) [7]. Pathak and Sanwal (1999) conducted an experiment on banana and found that soaking them in 0.2% GA_3 helped in reducing ripening rate based on fruit weight and pulp peel ratio. Mature and fully developed banana fruits of uniform size were maintained by increasing shelf life, reduced weight loss, increase in Total soluble solid content, reducing sugar, titrable acidity and ascorbic acid (Pinaki *et al*, 1997) [15].

Conclusion

Finger drop, being a very problematic issue for banana growers and traders, is having its importance among recent trends in agricultural research. Shelf life and quality are main criteria for both consumers and fruit growers. Good orchard management and post harvest management practices will be required to overcome this hurdle. This review article will be helpful for researchers to find out new idea and to develop new technologies to restore post harvest quality of banana for longer period.

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