

## **SURVEY OF MECHANICAL INJURY IN ‘PRATA ANÃ’ BANANA DURING SHIPPING**

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**Abstract** - Banana sold in the internal Brazilian market has low quality due to the presence of bruises spots spread all over the skin. In this work, the purpose was to evaluate the mechanical injury intensity in Prata Anã bananas as related to packaging type, at harvesting and during postharvest handling steps. Fruits were harvested at green unripe stage from a commercial plantation in Janaúba-MG, in July and in November 2003, and were transported to Viçosa-MG, about 800 km far way, packed in wood crates ‘torito’ + cardboard, ‘plastic’ and ‘cardboard’ boxes. Regardless the season of harvest, at least 93% of the fruits showed some kind mechanical wounding on the skin after shipping. But, the total surface skin area damaged was significantly higher during the month of November (spring) compared to July (winter) for all three different boxes. Bananas shipped inside cardboard boxes had larger wounding areas compared to ‘torito’ + cardboard and plastic boxes. Among the postharvest handling steps, which included, harvest, transport by aerial cable, preparation of finger and shipping, the last was most damaging to the fruit surface. However, the extent of wounding imposed to the fruits after had been shipped, did affect the course of ripening.

**Index terms:** *Musa* spp., skin color, bruises, ripening

## **LEVANTAMIENTO DE INJÚRIA MECÁNICA EN BANANA PLATA ENANA DURANTE EL TRANSPORTE**

**Resumen** - La banana vendida en el mercado interno brasileño tiene baja calidad, debido a la presencia de manchas puntuais esparcidos por toda la cáscara. En este trabajo, el objetivo fue cuantificar y evaluar la intensidad de injurias mecánicas en la banana Plata Enana en función del tipo de embalagem, de la época de cosecha y del manuseio post-cosecha. Frutos colhidos verdes en plantios comerciales de Janaúba-MG, en julio y en noviembre de 2003, fueron acondicionados en cajas ‘torito’ + papelão, ‘plástica’ y ‘papelão’ y transportados para Viçosa-MG, a 800 km de distancia. Independientemente de la época de cosecha, por lo menos 93% de los frutos mostraron algún tipo de herida mecánica en la cáscara después de la expedición. Sin embargo, la superficie total de área de la cáscara damnificada fue significativamente mayor durante el mes de noviembre (primavera) en comparación con julio (invierno) para las tres cajas diferentes. Bananas transportadas dentro de cajas de papelão tuvieron herida con áreas mayores en comparación con 'Torito' + papelão y cajas plásticas. Entre las etapas de manuseio post-cosecha, que incluyó, cosecha, transporte por cabo aéreo, preparación y expedición, la última fue de más perjudicial para la superficie del fruto. Sin embargo, la extensión de la herida impuestas a los frutos después del transporte, no afectó el curso de amadurecimiento.

**Términos para indexación:** *Musa* spp., color de la cáscara, lesiones, amadurecimiento

## LEVANTAMENTO DE INJÚRIA MECÂNICA EM BANANA PRATA ANÃ DURANTE O TRANSPORTE

**Resumo** - A banana vendida no mercado interno brasileiro tem baixa qualidade, devido à presença de manchas pontuais espalhados por toda a casca. Neste trabalho, o objetivo foi quantificar e avaliar a intensidade de injúrias mecânicas na banana Prata Anã em função do tipo de embalagem, da época de colheita e do manuseio pós-colheita. Frutos colhidos verdes em plantios comerciais de Janaúba-MG, em julho e em novembro de 2003, foram acondicionados em caixas 'torito' + papelão, 'plástica' e 'papelão' e transportados para Viçosa-MG, a 800 km de distância. Independentemente da época de colheita, pelo menos 93% dos frutos mostraram algum tipo de ferimento mecânico na casca após a expedição. Porém, a superfície total de área da casca danificada foi significativamente maior durante o mês de novembro (primavera) em comparação com julho (inverno) para as três caixas diferentes. Bananas transportadas dentro de caixas de papelão tiveram ferimento com áreas maiores em comparação com 'Torito' + papelão e caixas plásticas. Entre as etapas de manuseio pós-colheita, que incluiu, colheita, transporte por cabo aéreo, preparação e expedição, a última foi a mais prejudicial para a superfície do fruto. No entanto, a extensão do ferimento impostas aos frutos após o transporte, não afetou o curso de amadurecimento.

**Termos para indexação:** *Musa* spp., cor da casca, lesões, amadurecimento

### INTRODUCTION

In the past decade, a growing region of banana plantations was established at northern of the Brazilian state of Minas Gerais. The plantations are located within the irrigated perimeter area of Jaiba river, being today one of the largest producing places in the whole Brazil. Approximately 90% of the plantations grown in the region were planted with the Prata Anã cultivar, which is a very popular variety of fruit consumed all over the country. The majority of the harvested product goes directly to wholesale central state run markets named CEASAS, located in metropolitan areas of Belo Horizonte and Rio de Janeiro in a distance by road, of approximately 600 to over 1000 km from the producing area. The fruit is harvested at mature green stage, separated in individual fingers and immediately transported in open trucks without refrigeration or adequate storage boxes. As general assumption, such handling and transporting procedures result in fruits with low internal and external quality when ripe.

In a general survey, Vigneault et al. (2002) verified that losses caused by mechanical injury in fresh fruits and vegetables are close to 20 to 25% in most Brazilian markets. But, the role of different types of packing boxes on quality, intensity of wounding and total losses of banana has not been investigated yet. However, in a previous work, 'Brazilian Dwarf' banana had the climacteric rise of respiration anticipated when the fruits were damaged by impact (MAIA et al., 2004). And by bruising fruits of banana cv. Gross Michael, with an area equivalent to one to four square centimeters, induced ethylene production and the subsequent hastening of ripening (MAGALHÃES et al., 2004). Maia et al. (2008) found that bruising and damage for compression were the two major mechanical damages observed in 'Prata Anã' banana throughout the chain of commercialization from the producing areas to the sales markets of manor cities in Southern Brazil.

Several boxes and packing material have been used to store and transport the banana fingers into the large Brazilian wholesale markets. The most common is the use of a wooden made box named 'torito', followed by plastic and in a less extend the use of cardboard boxes. Evaluation of external mechanical wounding in fruits packed in the 'torito' box is high, due to compression and surface bruising (MAIA et al., 2008). Such injuries are mainly caused by the roughness of the plain wood and by the edges of the box. To reduce losses and make the handling easier, producers usually place a cardboard box inside the 'torito' (VIVIANI et al., 2007). In this work the authors, found no difference among samples analyzed direct at wholesale market regarding to quality of bananas removed from 'torito', 'torito' + cardboard box and cardboard box. But, it is not clearly shown if the mechanical damage imposed by the handling affected the development of browning symptoms on the surface of the fruits after ripening was induced.

The purpose of this study was to exam the effects of three kinds of boxes used for storage and transportation during two different harvest seasons on the mechanical injury incidence in banana fruits.

### MATERIAL AND METHODS

Banana fruits (*Musa* spp., group AAB, cv. Prata Anã) were harvested in a commercial plantation located in municipal county of Janaúba (15° 47' S and 43° 18' W) at stage 1 according to the skin color (Burg and Burg, 1962), the bunches were transported by aerial cable to the packing house, where they were selected, separated in individual hands and washed in water containing neutral detergent and 0.03% aluminum sulfate. The experiment was repeated twice in two distinct seasons, during the months of July and November, respectively.

The individual fruit hands were placed in cardboard boxes (52 × 39 × 24.5 cm) containing approximately 18 kg of fruits, inside the plastic boxes (56

× 36 × 23 cm) were wrapped in low density perforated polyethylene bag, totalizing 20 kg fruit load capacity. Or alternatively, the fruits were placed in the traditional rough wooden boxes 'torito' used in most part of the country, with capacity for 22 kg of fruits, containing a cardboard box fitted inside the 'torito' as showed by Viviani et al. (2007). After, the boxes were transported by pavement road to the municipal county of Viçosa, located 800 km away from the packing warehouse, in a regular commercial delivery trip. The truck load was 4.5 to 5 m height and at arrival in Viçosa, box samples were removed from the load, and the fruits were kept at 20 °C and 90 % RH until reaching the stage 6 of ripening or 100% yellow skin to determined the percentage of surface injury among the treatments.

Total number of fruits and the surface of banana skin injured by bruising were determined in sample of boxes at arrival to the final destination. Injured area was measured by drawing the brown dark area from the skin to a piece of paper, which was passed through a leaf area meter.

The skin color was determined objectively using chromameter Minolta, as recommended by Chen e Ramaswamy (2002) for every stage of ripening. The results were expressed as  $E = (L^2 + a^2 + b^2)^{0.5}$ . The total soluble solids from the fruit pulp were determined using a bench refractometer Abbé.

The experiments were arranged in a complete random design and the data were subjected to

analysis of variance (ANOVA). When appropriated means separation was separated by Tukey test at  $P = 0.05$ .

## RESULTS AND DISCUSSION

The largest amount of finger per box was found in the plastic container, a total of 67, comprising an average of 521 fruits with a 100 of the fruits showing bruises (Table 1). A reduction of 7% in the percentage of bruised fruits was present within the cardboard box, but when the cardboard box was fit inside the wooden 'torito', again 100% were injured, similar to the plastic container (Table 1). Regardless the fact that the cardboard 'torito' + cardboard box had 96 fruits less per box compared to the plastic box, they had 100% injured fruits after being transported. In banana, the percentage of injured fruits is higher to those found for plums and nectarines at wholesale market in the Brazilian state of São Paulo, ranging from 8.73% in plum to 44.5% in nectarines (AMORIM et al., 2008). Thus, banana fruit behaves as a very sensitive fruit to mechanical injury, since regardless the kind o box used for transportation near to 100% of the fruits were damaged externally. The general aspect of the fruits at arrival at destination is shown in the Figure 1. Because the fruits are still at mature green stage it is not possible, at arrival in Viçosa, to identify yet if the bruises will affect the ripening.

Table 1. Injured banana fruits found in three different boxes after transported by road from the municipal county of Janaúba to Viçosa, MG, Brazil.

Boxes	Number of	Fingers/box	Number of	Fruits/finger	Number of	Injured fruits
Torito + Cardboard	3	18	53	8	425	100
Cardboard	3	22	67	8	521	100
Plastic Cardboard	3	18	54	8	444	93

Regardless the kind of box utilized, during the month of July the injured area per fruit was similar, throughout the month of November, the box 'torito' + cardboard was lower compared to cardboard (Table 2). And during this month, the plastic box had an intermediate behavior regarding the total area of mechanical damage per fruit. Always the total area injured per fruits was higher during the month of November

independently the kind of box utilized (Table 2). Such behavior might be related to the higher temperatures that occur during the month of November, compared to the winter month of July. Thus, the elevated temperatures could have enhanced de dark spots on the skin due to more active polyphenol oxidase, responsible for the darkening of banana skin (NGUYEN et al., 2003).

Table 2. Percentage of injured surface area in three different packing boxes of banana, in July and November seasons after transported by road from the municipal county of Janaúba to Viçosa, MG, Brazil.

Boxes	Total injured area (%)	
	July	November
Torito + Cardboard	3.7 aB	6.7 bA
Plastic	5.0 aB	7.3 bA
Cardboard	4.2 aB	9.9 aA

Means with the same lowercase letter in the columns and uppercase in the lanes do not differ statistically by Tukey test at  $P = 0.05$ .

When expressed in percentage of injured area per fruit, no differences were detected during July, which ranged from 3.7% for 'torito' + cardboard box to 5.0% for plastic (Table 3). On the other hand during the month of November the cardboard box showed significantly higher percentage of area injured compared to 'torito' + cardboard and plastic boxes (Table 3), and the highest area of 9.9% was determined for the banana placed in cardboard through the month of November. And, regardless the kind of box used; in November the

area injured in each fruit was always more elevated than July (Table 3). In November, the area damaged per fruit jumped by 1.8-fold for 'torito' + cardboard, 1.5-fold for plastic and 2.4-fold for cardboard, compared to the month of July (Table 3). The total percentage of injured area per fruit was small after has been transported less than 10%, thus the visual damage seems to be restricted to the area that suffer the impact and the browning was not spread to the whole fruit.

Table 3. Total injured surface area in three different packing boxes of banana, in July and November seasons after transported by road from the municipal county of Janaúba to Viçosa, MG, Brazil.

Boxes	cm <sup>2</sup> /fruit	
	July	November
Torito + Cardboard	9.0 aB	18.9 bA
Plastic	11.3 aB	20.6 abA
Cardboard	8.1 aB	25.5 aA

Means with the same lowercase letter in the columns and uppercase in the lanes do not differ statistically by Tukey test at  $P = 0.05$ .

Independently the box used, the total injured area per fruit was significantly higher during the month of November compared to July. Bananas stored in cardboard had the highest increase in area, 3.2-fold compared to the month of July, followed by 2.1-fold for 'torito' + cardboard and 1.8-fold for plastic (Table 3). The lower increase in the total injured area found in November

in relation to July, might be due to a better ventilation inside the box, compared to cardboard and 'torito' + cardboard due to the absence of wrapping plastic and presence of holes on the plastic box (Figure 1). This could lower the temperature inside the box, reducing the rate of browning oxidative reactions in the peel.

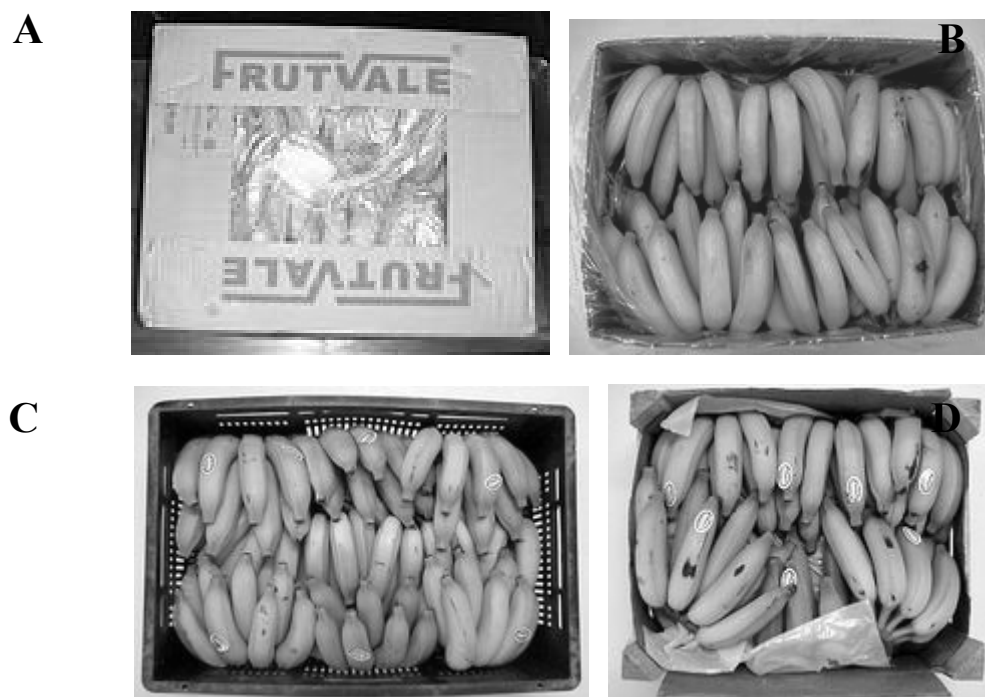


Figure 1. Boxes used for the packaging and transportation of banana from Janaúba to Viçosa. A and B – Close and open cardboard box; C – Plastic box; D – Torito + Cardboard box.

At harvest a total area of 6.9 cm<sup>2</sup> per fruit was showing already some kind of mechanical injury at the field, corresponding a 3.2% of the total area of an individual bunch (Table 4). After transporting the whole banana bunches by aerial cable, no significant increase was detectable in the total wounding area compared the damage regions found at harvest. But a significant

enhance in the wounding area occurred during the fingers preparation for transport. The steps included cutting off the finger and washing them in tank with water and boxing. In these operations at the packinghouse, the total wounded area of 4.4% jumped to 5.9%, corresponding a 34% increased (Table 4).

Table 4. Mechanical injury on the surface of banana fruits through handling and shipping.

Step	Surface injured	
	cm <sup>2</sup> /fruit	(%)
Harvest	6.9 c	3.2 c
Aerial cable	7.5 c	4.4 bc
Preparation of fingers	11.5 b	5.9 b
After shipping	23.0 a	12.0 a

Means with the same letter in the columns do not differ statistically by Tukey test at  $P = 0.05$ .

Regardless the season of harvest or the box used for shipping, the largest injured of 23 cm<sup>2</sup>/fruit was measured after the bananas were transported to Viçosa, corresponding to an increase of 103% in wounded area compared to the damage found after the preparation of

finger (Table 4). As the shipping can be consider the longest step of all and also the most susceptible to environmental stresses, the injury was amplified when compared to the previous handling procedures. Maia et al. (2008) found similar trend of wounding for bananas

belonging to same variety analyzed after standing eight hours in a retail store.

After one day of arrival in Viçosa, it started noticeable changes on the skin color and rising in the total soluble solids of banana pulp (Figure 2). Regardless the kind of box used the color index 7 and maximum total soluble solids of 25% were reached after eight to nine days of arrival in Viçosa (Figure 2). This in this experiment, the extent of wounding caused by any used

boxes, did not hasten the ripening of banana fruits. It is well known that abiotic stresses including postharvest water dehydration and mechanical wounding, depending on the intensity, may induce ripening in climacteric fruits such as banana (FINGER et al. 1995) and kiwifruit (MENCARELLI et al. 1996). In these fruits of banana, the range of surface damage induced by the shipping, in any of the different kind boxes, was not enough to trigger immediately ripening.

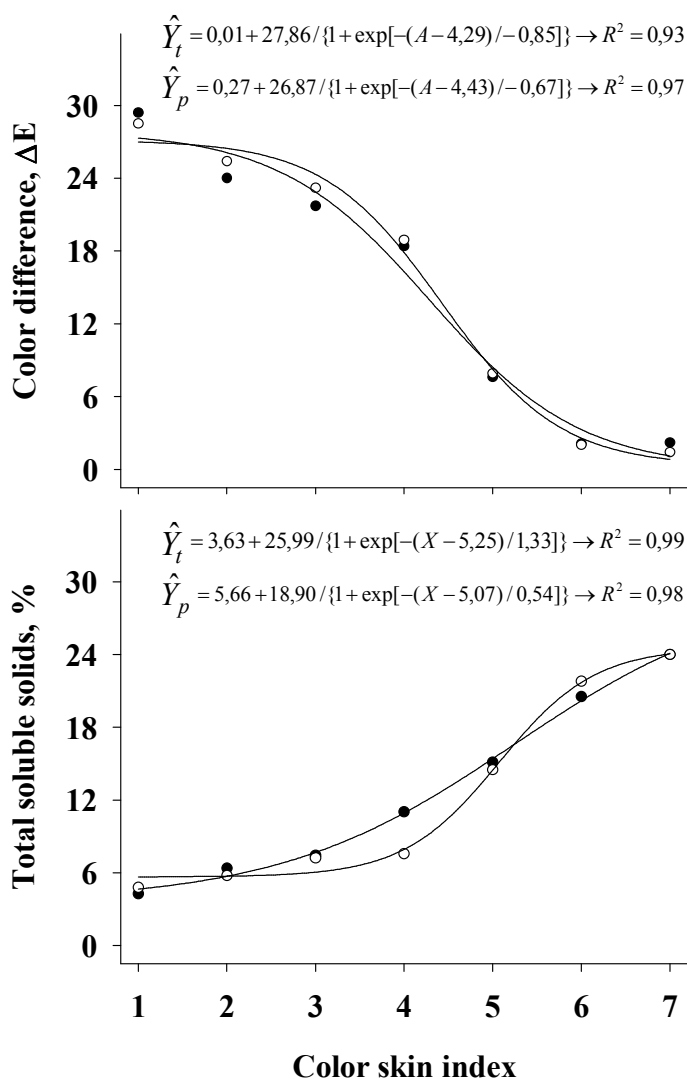


Figure 2. Changes in color and total soluble solids during ripening in banana transported from Janaúba to Viçosa, MG shipped in (●) Torito + Cardboard and (○) Cardboard box.

## CONCLUSIONS

1. The incidence of mechanical injury in fruit proved to be widespread in bananas shipped in three of the sales packaging ('torito' + cardboard, plastic and cardboard).

2. The levels of mechanical injury were higher on the surface of the skin of the fruit sampled in November 2003 compared for fruit sampled in July of that year.

3. The progress of the postharvest handling steps, which included, harvest, transport by aerial cable, preparation of finger and shipping, resulted in an increase in the index of physical damage on the peel surfaces of the fruit.

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