

METABOLIC ALTERATIONS IN BANANA INDUCED BY MECHANICAL DAMAGE

Alterações metabólicas em bananas induzidas por dano mecânico

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Abstract: Objective: Bananas respond at the physical and physiological level to mechanical damage. Mechanical injuries cause alterations in color and flavor, tissue softening, faster ripening, increased weight loss, increased invasion of microorganisms, and higher enzyme activity in the affected area. The present study aimed was to verify the metabolic alterations in ‘Dwarf Prata’ bananas induced by mechanical stress and stored at room condition (25.4 °C, 82% RH). **Methods:** Was used split-plot in time design, consisting of one control and four mechanical injury types: cutting, abrasion, impact and compression, sampled over time. Samples were collected within a period of 9 days, based on a completely randomized design with 3 replications and 3 fruits per plot. **Results:** The evolution of the peel color and fruit respiration were measured. The peel color grade 6 was only exceeded in fruits damaged by abrasion and impact, while the others came quite close to this grade. The greater speed of impact-damaged fruit in reaching peel color grade 6, a completely yellow peel, can be explained by the anticipation of the climacteric respiratory peak in fruits of this treatment compared to the control and the other mechanical damage types, which showed no production peak of CO₂ before the control. Mechanical damage stimulates respiratory process and ethylene biosynthesis. **Conclusion:** The impact damage anticipated the ripening.

Keywords: Musa spp. Injury. Ripening.

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Resumo: Objetivo: Bananas apresentam respostas físicas e fisiológicas ao dano mecânico. As injúrias mecânicas causam alterações na cor e sabor, amaciamento dos tecidos, amadurecimento mais rápido, aumento na perda de peso, aumento no ataque e invasão de microorganismos e maior atividade enzimática na área afetada. O presente trabalho objetivou foi verificar as alterações metabólicas induzidas por estresse mecânico em bananas ‘Prata Anã’ mantidas em condição de ambiente (25,4 °C, 82% UR). **Metodologia:** Foi utilizado o esquema em parcelas subdivididas no tempo, constituído de testemunha e quatro fontes de dano mecânico: corte, abrasão, impacto e compressão. As amostras foram coletadas no período de 9 dias, com base em um delineamento experimental inteiramente casualizado com 3 repetições e 3 frutas por parcela. **Resultados:** Foram avaliadas a evolução de cor da casca e a respiração dos frutos. O estágio de cor da casca 6 só foi ultrapassado em frutos danificados por abrasão e impacto. A maior velocidade de frutas danificada pelo impacto no alcance estágio de cor da casca 6, uma casca completamente amarela, pode ser explicada pela antecipação do pico climatérico respiratório em frutos desse tratamento, em comparação com o testemunha e os outros tipos de dano mecânico, que não mostrou qualquer pico de produção de CO₂, antes da testemunha. Danos mecânicos estimula o processo respiratório e síntese de etileno. **Conclusão:** O dano por impacto antecipou o pico climatérico e o amadurecimento dos frutos.

Palavras-chave: Musa spp. Injúria. Amadurecimento.

INTRODUCTION

Brazil is the fourth largest producer of bananas, with 7,193 million tons produced in 511,000 ha, resulting in average yield of 14.1 t ha⁻¹, and the per capita consumption is 30.76 kg yr⁻¹. Production and consumption in Brazil show very peculiar characteristics, prevailing in most Brazilian regions the dessert varieties, such as AAB bananas, Prata type, 'Dwarf Prata', 'Pacovan' and 'Common Prata', which represent about 80%.

Mechanical damage can occur at any point in the supply chain of 'Dwarf Prata' banana³ due to the technology used at harvest and post harvest. Bananas respond at the physical and physiological level to mechanical damage. Physical responses are mainly linked to the appearance, with the surge of symptoms of advanced lignification and necrosis in the damaged region⁴. Due to the physiological responses, mechanical injuries cause alterations in color and flavor, tissue softening, faster ripening due to the increase in respiration and ethylene production, increased weight loss, and invasion of microorganisms⁴⁻¹¹.

Ferris et al.¹² and Ferris et al.¹³ studied plantain genotypes and environmental conditions, and observed that abrasion damage reduced the ripening period and increased the loss rate of fresh fruit weight. In this study was found that impact damage reduced the ripening period of fruit harvested at 85 days after flowering. Cutting also caused a reduction in ripening period without influencing weight loss, compared with the control fruits. However, compression damage had no effect on the characteristics evaluated, compared to undamaged fruits. Compression injuries can

lead to the breaking of epidermis cells, triggering enzymatic reactions and, consequently, darkening of areas around the affected location, due to leakage and exposure of the cell liquid to enzyme action, inducing oxidation of phenolic compounds to quinones¹⁴. Zhou et al.¹⁵ also observed that mechanical damage affected plasma membrane of pear. The damage caused by cutting and abrasion resulted in the highest percentage of fresh weight loss.

In banana cutting, abrasion, impact and compression increased electrolyte leakage. The impact damage anticipated the ripening, besides affecting the conversion of starch into total soluble sugars in the pulp. The polyphenoloxidase and peroxidase activity in the banana peel was increased by impact and abrasion injuries¹⁶.

There are few studies on the effects of mechanical damage on banana. The purpose of this study was to verify the metabolic changes induced by mechanical stress in 'Dwarf Prata' banana stored at room condition.

METHODOLOGY

The experiment was conducted in laboratories of the Universidade Federal de Viçosa (UFV), with bananas (AAB) from the commercial orchard in Verdelândia, state of Minas Gerais (15 ° 24' S; 43 ° 43' W; 480 m asl, climate classification Aw, according to Köppen).

The experiment was conducted as split-plot in time analysis, where the treatments consisted of: T1 – control without mechanical damage and four types of mechanical damage: T2 – cutting, T3 – abrasion, T4 – impact, and T5 – pressure or com-

pression. Samples were collected within a period of 9 days, based on a completely randomized design with 3 replications and 3 fruits per plot.

The bunches were collected and the central fruits of the second hand had reached a diameter of 36 ± 2 mm. After harvesting the second, the third and fourth hand of each bunch were also removed, washed, identified, wrapped in bubble plastic and packed in corrugated boxes. The boxes were transported to the PostHarvest Laboratory, UFV, where they were labeled by a cut close to the flower cushion and washed in a 0.2% detergent solution for five minutes. Thereafter, the fruits were padded in plastic boxes lined with shredded paper and stored at room condition (25.4 ± 1.9 °C and 82 ± 9.1 % relative humidity), until and after the treatments.

Fruits with a completely green peel or peel color 1⁵, were damaged by impact, pressure or compression, abrasion, and cutting. The fruits were damaged, one by one, in the central region, between two nooks, on two areas of 10 cm² each (2 cm by 5 cm), totaling 20 cm².

Cutting was performed with a stylus in three 5 cm long cuts, spaced 1 cm apart, to a depth of 2 mm. Other fruits were abraded by rubbing sand paper No 80 over the previously delimited area. Fruits were impact-damaged according to a methodology described by Dadzie e Orchard⁵, by letting a steel ball (66 gr) drop on the fruits from a height of 1.5 meters. The impact energy was 971.2 mJ. The fruits were damaged by compression by maintaining a weight of 3 kg for 5 minutes on the fruits.

The following characteristics were evaluated: color evolution, according to the peel color

grade based on a 1 to 7 scale of colors⁵; and fruit respiration by gas chromatography, in mg of CO₂ produced by 1 kg of fruit within 1 hour. These assessments were determined daily in duplicate samples, consisting of three fruits each.

The rates of CO₂ emission were determined by gas chromatography, in a Gow-Mac 550 thermal conductivity gas chromatograph (Gow Mac Instrument Co., Bound Brook,NJ), equipped with a detector of thermal conductivity in aluminum and a column packed with Porapak Q.

RESULTS AND DISCUSSION

The peel color grade of fruits in all treatments changed during the evaluation period (Figure 1). Rocha et al.¹⁷ observed a similar performance in 'Prata' banana. The mechanisms underlying this phenomenon are chlorophyll degradation in the peel tissues and consequent appearance of the already existing carotenoids¹⁸. The peel color grade 6 was only exceeded in fruits damaged by abrasion and impact, while the others came quite close to this grade (Figure 1). Moreover, the impact-damaged fruits reached the peel color grade 6 on the 5th day of evaluation. However, abraded fruits reached and surpassed this grade on the last day of evaluation (9th day). These results indicate that chlorophyll degradation in fruits damaged by impact was faster. The consequence is a reduced shelf life of these fruits, since the peel color is used as an indicator of fruit maturation.

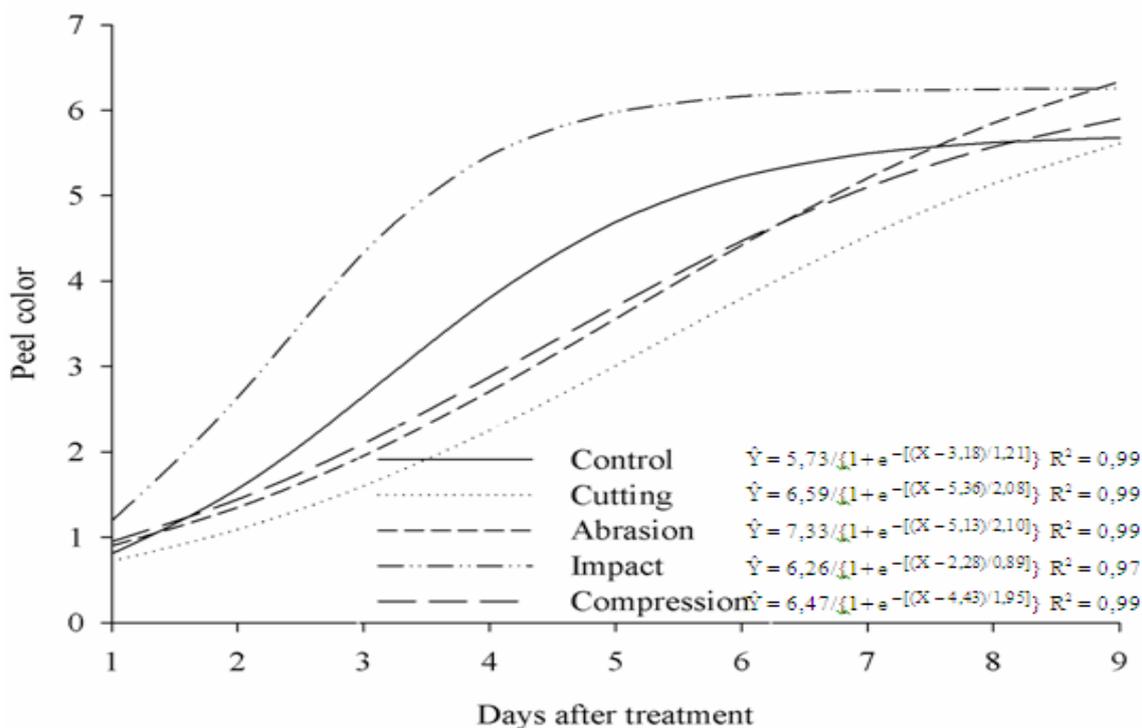


Figure 1. Evolution of the peel color rating of ‘Dwarf Prata’ bananas during the storage period at 25.4 °C and 82 % relative humidity, as related to the different types of mechanical damage.

The greater speed of impact-damaged fruit in reaching peel color grade 6, in other words, a completely yellow peel, can be explained by the anticipation of the climacteric respiratory peak in fruits of this treatment compared to the control and the other mechanical damage types, which showed no production peak of CO₂ before the control (Figure 2).

The magnitude of the climacteric peak was higher in injured than unwounded fruits. Strehmel et. al.¹⁹ also observed changes in potato respiratory activity after mechanical damage. However, Steffens et. al.²⁰ observed no change in respiratory activity of apples subjected to impact injury. Fruits damaged by cutting, abrasion, impact and compression reached a peak CO₂ production of 172.9,

187.3, 205.0 and 172.1 mg CO₂ kg⁻¹ h⁻¹, respectively, while the control reached 154.1 mg CO₂ kg⁻¹ h⁻¹ (Figure 2). These higher values of CO₂ production at the climacteric peak may be related to responses of defense and scarring, for which the fruits spend respiration energy. Mechanical damage stimulates respiratory process and ethylene biosynthesis. The consequence is increased activity of enzymes and starch degradation by α -amylase, β -amylase and glucosidases. The action of these enzymes increases more rapid degradation and the available quantity of sucrose and glucose, which are respiratory substrates leading to higher respiration rate in mechanically damaged fruits^{9,21}. All these factors lead to the higher consumption of respiratory substrates.

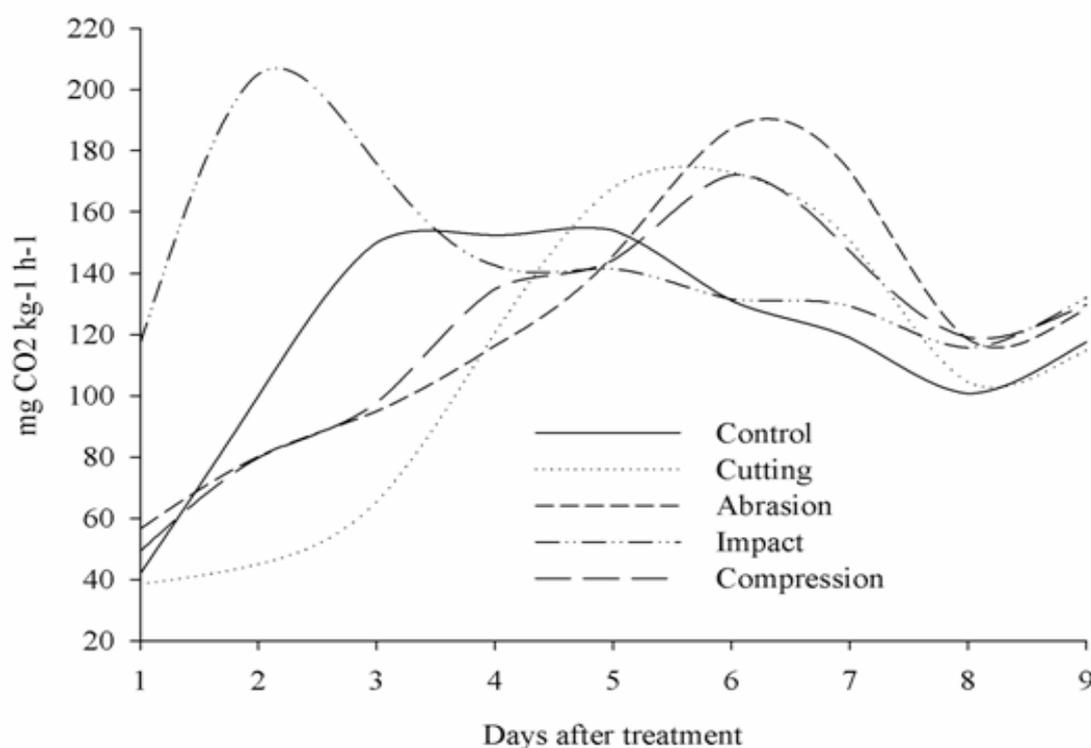


Figure 2. Respiration rate of 'Dwarf Prata' bananas during the storage period at 25.4 °C and 82 % relative humidity, as related to the different types of mechanical damage.

CONCLUSION

Impact damage anticipated the climacteric peak and ripening of 'Dwarf Prata' bananas.

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