ISSN 0100-2945 http://dx.doi.org/10.1590/0100-29452017939

PHYSICAL-CHEMICAL QUALITY OF MANGO 'Ubá' (*Mangifera indica* L.) FRUITS SUBMITTED TO IMPACT MECHANICAL DAMAGE AT HARVEST [1]

ANÁLIA LÚCIA VIEIRA PACHECO[2], KARINA SCHULZ BORGES[3], GERIVAL VIEIRA[4], GILBERTO BERNARDO DE FREITAS[5], PAULO ROBERTO CECON[6]

ABSTRACT-The objective of this study was to evaluate the quality of 'Ubá' mango fruit submitted to mechanical damage. The fruits were harvested in the 2012/2013 harvest, and let to drop once on a flat, hard surface, simulating the harvesting process of 'Ubá' mango, which is to drop all the fruits of a plant when they are physiologically mature. Treatments consisted of different drop heights (zero, one, two, three, four and five meters), totaling six treatments. After the fall, the fruits were submitted to ripening, and then evaluated for fresh mass loss (FML), presence of external lesions (PEL), presence of internal lesions (PIL), soluble solids content (SS),titratable acidity (TA), pH, SS/TA ratio and vitamin C. There was no difference between fresh weight loss of the dropped fruits and control. Regarding the presence of external and internal lesions, damage in fruits due to drop height tends to increase. The fruits that were not dropped presented higher SS content than the others, while those that fell from a height of 5 m had the vitamin C content reduced by 27.78% compared to control. The decrease in SS content and vitamin C was influenced by damage caused by the impact. It is concluded that mechanical damage caused by the impact interferes in the main attributes of quality of fruits and pulp of "Ubá" mango.
Index terms: harvest, mango for industry, mechanical damage, pulp quality.

QUALIDADE FÍSICO-QUÍMICA DE FRUTOS DE MANGA 'UBÁ' (*Mangifera indica* L.) SUBMETIDOS À INJÚRIA MECÂNICA DE IMPACTO DURANTE A COLHEITA

RESUMO- O objetivo deste trabalho foi avaliar a qualidade da manga 'Ubá' submetida à injúria mecânica de impacto. Os frutos foram colhidos, na safra 2012/2013, e deixados cair uma única vez sobre uma superfície plana e rígida, simulando o processo de colheita da manga 'Ubá', que consiste em derrubar todos os frutos de uma planta, quando os mesmos encontram se fisiologicamente maduros. As alturas de queda: zero, um, dois, três, quatro e cinco metros, formaram seis tratamentos. Após a queda, os frutos foram submetidos ao amadurecimento, e em seguida avaliados em relação à perda de massa fresca (PMF), presença de lesões externas (PLE), presença de lesões internas (PLI), teor de sólidos solúveis (SS), acidez titulável (AT), pH, relação SS/AT e vitamina C. Não houve diferença entre a perda de massa fresca dos frutos que sofreram queda e o controle. Com relação à PLE e PLI, a tendência é de aumento da injúria nos frutos relacionada a altura de queda. Os frutos que não sofreram queda apresentaram maior teor de SS que os demais, enquanto que os que caíram de uma altura de 5 m tiveram o teor de vitamina C reduzido em 27,78% em relação ao controle. A diminuição do teor de SS e vitamina C foi influenciada pelos danos provocados pelo impacto. Conclui-se que injúrias mecânicas de impacto interferem nos principais atributos de qualidade dos frutos e da polpa de manga 'Ubá'.
Termos para indexação: colheita, danos mecânicos, manga para indústria, qualidade da polpa.

[1](Paper 267-15). Receoved pm December 07, 2015. Accepted June 02, 2016.. Part of the Master's Dissertation in Plant Science of the First Author.
[2]M.Sc., PhD in Plant Science, Federal University of Viçosa, Department of Plant Science, UFV, 3670-000 Viçosa, Minas Gerais, Brasil. Email: analia.pacheco@ufv.br
[3]M.Sc in Plant Science, Federal University of Viçosa, Department of Plant Science, UFV, 3670-000 Viçosa, Minas Gerais, Brasil. Email: karina.schulz.borges@gmail.com
[4]Professor D.Sc., Department of Plant Science, Federal University of Viçosa, UFV, 3670-000 Viçosa, Minas Gerais, Brasil. Email: gerival@ufv.br
[5]Professor D.Sc., Department of Plant Science, Federal University of Viçosa, UFV, 3670-000 Viçosa, Minas Gerais, Brasil. Email: bernardo@ufv.br
[6]Professor at the Department of Statistic, Federal University of Viçosa, UFV, 3670-000 Viçosa, Minas Gerais, Brasil. Email: cecon@ufv.br

INTRODUCTION

The mango “Ubá” is the most important variety produced in the region of Zona da Mata of Minas Gerais state. It is eaten fresh due to its excellent qualities of taste, smell and texture; however, most fruits are industrialized as concentrated pulp, simple pulp, ready to drink juice and nectars (BENEVIDES et al., 2008). Moreover, fruits of this variety are an excellent source of natural antioxidants, with β-carotene and vitamin C contents higher than those commonly found in other varieties of mango, which can contribute to meet much of the daily requirement of vitamin A and C (MATA et al ., 2011). In the Zona da Mata region, the production of this variety is concentrated between the months of December and January and although it stands out all over the country in the production of mango ‘Ubá’, the management of orchards adopted by farmers in the area still occurs in a traditional way, that is, without the use of appropriate technologies for management and harvesting of fruits.

Thus, the fruit arriving at agricultural industries differs in quality, which may be related to the high genetic variability, for most of them are plants from sexual propagation, and by the management systems adopted by the producers before and after harvest. Many of these farmers use in the fruit harvest, the “overall fruit dropping” process, which consists in dropping all the fruits of the tree when they present a partially yellowish pulp. In the process, due to the high size of the plants, the fruits fall from different heights, and as a result of the drop height or of the protection they found on the ground, drop site, the fruit suffers serious mechanical damage (PACHECO et al., 2015).

Quantification losses due to mechanical damage that ends up in disposal are scarce; however, according to IBRAF data (2005), losses for fruits may reach 40%, corresponding to 10 million t.year $^{-1}$. Mechanical damages are present in 77% of the total losses in apples (*Malus domestica*), 74.3% in pears (*Pyrus communis*), 43.2% in nectarines (*Prunus persica* L. var. Nucipersica) and 53.7% in peaches (*Prunus persica*) (CHITARRA; CHITARRA, 2005).

Several types of fruits and vegetables have been studied in relation to the implications arising from mechanical damages applied to these products, either during harvesting, processing, storage and/or transportation (SANCHES et al, 2008; HENDGES et al., 2011; BASSAN et al., 2016). However, studies on the implications that the damage by impact occurred at harvest may cause in mango ‘Ubá” fruit are still few.

Therefore, to understand the consequences of mechanical damages the mango ‘Ubá’ fruit suffers at harvest, and how the damage affects the quality of pulp, it was evaluated the fresh weight loss percentage (PMF), the percentage of fruit with internal lesions (PIL), the percentage of fruit with external lesions (PEL), the content of soluble solids (SS), titratable acidity (TA), pH, SS/TA ratio and the content of vitamin C.

MATERIAL AND METHODS

The fruits of mango ‘Ubá’ were harvested in the orchard of Experimental Seeding Farm, owned by the Federal University of Viçosa (UFV), located in Visconde do Rio Branco, state of Minas Gerais, latitude 21°00’37”S, longitude 42°50’26’’ W at an altitude of 352 m. According to Koppen classification, the climate in the region is Aw (savannah climate) and is characterized by average annual temperature of 21°C, average rainfall of 1,270 mm and average relative humidity of 80%. The orchard was established in 2007 by planting grafted seedlings of ‘Ubá’ mango tree, spaced by 10 x 10 m. Fertilization planting, formation and production were carried out according to the recommendations for the crop. In the first two years of cultivation, fruit produced by the mango trees were removed in order to allow a proper vegetative growth. The orchard was conducted without irrigation, which is the way most practiced by the fruit growers of the region. The plants did not receive phytosanitary treatment and only weed control was carried out on the projection region of the crown of the plant during mineral fertilization.

Harvest was conducted between the 16th and 17th week after anthesis, characterized as physiological maturity when fruits displayed yellow pulp, according to the classification guidelines for mango fruits (CEAGESP, 2004).

After the manual harvest, the fruits were transported to the Laboratory of Physiology, Management and Quality of Postharvest Fruits at the Federal University of Viçosa. For batch homogenization, fruits were selected for size, coloration of the peel and absence of pre-existing mechanical damage. After that, fruits were sanitized by soaking in sodium hypochlorite 100 mg L^{-1} of active chlorine for 1 minute and dried at room temperature. Sample analyzes of fruits were performed to determine its initial quality, and its initial fresh weight was weighed by using electronic scales before application of treatments.

The fruits were let to fall on a flat, hard surface only once. Each drop height corresponded to a treatment: 0 (control), 1, 2, 3, 4 and 5 meters, totaling six treatments. Each plot consisted of eight fruits, with five replicates for each treatment. After application of the treatments, the fruits were placed in plastic boxes and acetylene was applied at a concentration of 1000 ppm to anticipate and uniform fruit ripening. Each box was packed with low density polyethylene (LDPE) bags of 20 µm thick, and sealed to form a ripening chamber. The treatments were arranged in randomized blocks in a room with temperature of 25°C ± 2°C, where they remained until ripening. Seventy-two hours later, the chambers were opened so the formed gases were released and three days later, the fruits had reached the desired maturity stage (more yellow than green color) for processing and laboratory analyses were started.

After being taken from the ripening chambers, the fruits had their fresh weight measured again. Fruits that presented external lesions were discarded, according to the procedure adopted by agricultural industries in the region. Disposal percentage generated by each treatment was calculated by counting the fruits removed from chambers unable for being processed. The fruits that had no external damage were peeled and evaluated for the presence of internal wounds such as brownish, soft and coalescing spots (QUINTANA; PAULL, 1993) and the percentage was calculated on the total number of fruits in each plot. After fruit peeling, regions of pulp with wounds were discarded.

Analyses were performed with the not wounded pulp, which was homogenized to obtain samples according to analytical standards of the Adolfo Lutz Institute (2008). Soluble solids content was determined by direct reading on portable of 0 to 32°Brix. Homogenized samples consisting of 5 ml of the pulp were used for measuring TA. Titration was performed under stirring, with NaOH 0.1 mol L^{-1} and results expressed in $g.100^{-1}g$ of anhydrous citric acid. The pH was determined in homogenized samples with a digital pH meter. The SS/TA ratio was obtained through direct quotient. The content of vitamin C was obtained by Tillmans method.

Data were analyzed using analysis of variance and the means of control variables were compared with the other treatments using the Dunnett test, adopting the 5% level of significance. Statistical analysis was performed using the Statistical and Genetics Analysis System of the Federal University of Viçosa, version 9.1(SAEG, 2007).

RESULTS AND DISCUSSION

No effect of the drop height was found in the fresh mass loss of the fruits (Table 1). Fresh mass loss is an early symptom of water loss (FONTES et al., 1999), and for vegetables, the losses of the order of 3% to 6% are enough to cause a marked decline in quality; however, some products with up to 10% of moisture loss are still marketable (CHITARRA; CHITARRA, 2005).

It was found in papayas (GODOY et al., 2010), avocados (SANCHES et al., 2008), oranges (MIRANDA et al., 2015) and peaches (KASAT et al., 2007) that the mechanical damage caused by the impact leads to larger mass loss in fruits. Overall, fresh mass loss of damaged fruits is measured over time. However, in this study, the fruits were evaluated immediately after being taken from the ripening chamber, with no storage period. There are no references regarding the fresh weight loss limit tolerated for “Ubá” mango. However, during commercialization, middlemen buy physiologically mature fruits from farmers, induce artificial ripening and subtract 10% of the number of boxes with harvested fruits related to the likely fresh mass loss during the process of maturing and transportation to the processing plants. Considering that fresh mass loss in this study was approximately 7%, the 10% value used by the middlemen is justifiable.

Presence of external lesions increased in fruits from the drop height of 3 m due to their decay. The highest drop height resulted in losses of 40.62 (Table 1). According to representatives of agricultural industries, the mechanical damages caused in fruits harvested by the ‘total dropping harvest’ method generate losses of primary and secondary order. The primary losses lead to disposal of the product during sorting of fruit on appropriate conveyor. The secondary losses are related to changes that do not necessarily lead to the immediate disposal of the product, but significantly alter the internal quality of the fruit, which can lead to dissatisfaction by the consumer (PACHECO et al., 2015). The impact results in a high risk of contamination by microorganisms during storage (BLASCO et al., 2003) as peel rupture often occurs. Thus, fruit with damaged epidermis due to the fall rotted before reaching maturation. Besides being discarded, those fruits become potential sources of contamination for others. Therefore, such losses are considered to be of primary order because they lead to the complete disposal of the fruit.

The presence of internal lesions increased from the drop height of 1 m. At 5 m of drop height, 82% of the fruit had internal lesions (Table 1). Tomatoes ‘Deborah’ showed an increase in the incidence of internal physical lesions as drop height was enhanced. Moreover, at 40 cm, 25% of total analyzed fruits had significant severe damages (CAMARGO et al., 2004). Apples submitted to damage from impact showed darkening of the pulp but with no symptoms observed in the epidermis of the fruit (HENDGES et al. 2011). The internal lesions were evaluated in fruits that did not show signs of mechanical damage on the external part, or fruit that would possibly be processed by the agricultural industry or commercialized for fresh consumption. The occurrence of injuries in many products may not cause readily observable external symptoms. However, the effect had an impact, eventually producing internal injuries (QUINTANA; PAULL, 1993; MORETTI et al. 1998). These internal injuries may manifest through changes in consistency and color of the pulp. The main explanation for such changes in the color of the pulp is the oxidation of phenolic substances by oxidative enzymes such as polyphenoloxidase producing dark colored compounds such as melanin (MONTERO et al., 2009). Guavas that were submitted to impacts did not present any visible symptoms visible in the outer pericarp; however, the stress caused by it produced an internal collapse in the locules of the fruit (MATTIUZ et al., 2002). The susceptibility to mechanical damage is influenced by several factors such as species, cultivar, and degree of cellular hydration, maturity stage, size, fresh mass, epidermal characteristics and environmental conditions (WADE; BAIN, 1980; KAYS, 1991).

As the fruits ripened, they presented an increase in the content of soluble solids of 4.00 for an average value of Brix of 17.76° (Table 2). The highest drop height reduced the soluble solid content in the control by 14.43%. In the pulp of the “Prata Anã” bananas, the impact anticipated and damaged the conversion of starch into soluble sugars (MAIA et al., 2011). In guava (MATTIUZ; DURIGAN, 2001) and acid lime ‘Tahiti’ (DURIGAN et al., 2005), damaged fruits revealed reductions in contents of soluble solids. However, differences in the content of soluble solids are not always found (ALVES et al. 2010; MONTERO et al., 2009). All the physical and chemical analyses conducted in this study were made with non-injured parts of the pulps of mango ‘Ubá’ fruits, showing that even the uninjured area of the fruit may have its content of soluble solids reduced.

At harvest, the fruits presented content of titratable acidity of 1.45 g.100^{-1}g expressed in anhydrous citric acid, and at the end, the average value of treatments was 0.61g.100^{-1}g (Table 2). The content of organic acids, with few exceptions, decreases with maturation due to the respiratory process or its conversion into sugars. The ripening period is the one with the highest metabolic activity (CHITARRA; CHITARRA, 2005). Mature mango ‘Ubá’ fruits may have variable values for titratable acidity, ranging from 0.46 g.100^{-1}g (SILVA et al., 2009) to 0.60 g.100^{-1}g (BENEVIDES et al., 2008). Only at the drop height of 3 m, did titratable acidity differed from the others (Table 2). In tomatoes ‘Deborah’, as drop height increased, a slight decrease occurred in the titratable acidity (CAMARGO et al., 2004). Also in peaches, titratable acidity was lower in damaged fruits (KASAT et al., 2007). However, influence of mechanical damage in the titratable acidity is not always found in the content of titratable acidy, as in avocados (SANCHES et al., 2008) and apples (STEFFENS et al., 2008).

From harvest to fruit ripening, pH and SS/TA ratio increased with no statistically differences between control and impacted fruits (Table 2). This increase reflects the reduction in the acidity occurred during fruit ripening (COUTINHO et al., 2003). In mango ‘Haden’ fruits, pH increased concomitantly to the reduction of titratable acidity during the ripening period (CARDELLO and CARDELLO, 1998). An increase in SS/TA ratio would be expected, but the titratable acidity and SS data did not always vary due to the impact height and because it is a direct quotient, this ratio tends to adjust according to its constituents.

The average content of vitamin C of the fruits was 70.27 mg/100g at harvest, and with the ripening, the average content of treatments was reduced to 50.17 mg /100g. Because vitamin C is involved in antioxidative mechanisms, it was found that the higher the fruit drop height, the greater is the damage to tissues, with an increased demand for vitamin C (Table 2). The content of vitamin C in the mango ‘Ubá’ fruits decreases with maturation (Silva et al., 2009; Mata et al., 2011.). In mango ‘Haden’ fruits, the content of vitamin C declined during the ripening period (CARDELLO; CARDELLO, 1998). The drop height of 5 m reduced 27.78% in the vitamin C content compared to the control. In acid lime ‘Tahiti’ submitted to fall impact, content of vitamin C was reduced by approximately 6% (DURIGAN et al., 2005); in ‘Montenegrina’ and ‘Rainha’ tangerines and ‘Murcott’ tangor, the reductions were 27, 24 and 20%, respectively, in treatments with the highest drop height compared to the control (MONTERO et al., 2009).

TABLE 1 – Percentage of fruits with external lesions (PEL), percentage of fruit with internal lesions (PIL) and fresh mass loss (FML) of fruits after being taken from the ripening chambers. 2012/2013 harvest.

Drop Height (m)	PEL	PIL	FML
Control	7,04 A	20,00 A	6,90 A
1	1,94 A	64,64 B	7,02 A
2	16,70 A	72,00 B	6,95 A
3	30,47 B	77,50 B	6,49 A
4	29,15 B	78,38 B	6,94 A
5	40,62 B	82,00 B	6,96 A
LSD	19,48	23,95	1,64

Means with the same letter to control in the column do not differ at the level of 5% of probability by the test of Dunnett.

TABLE 2 – Soluble solids (SS), titrable acidity (TA), pH, SS/TA ratio, content of vitamin C (Vit. C) at harvest and after removal from rippening chambers. 2012/2013 Harvest.

Drop Height (m)	SS	TA	pH	SS/TA	Vit. C
Harvest	4,00	1,45	3,06	2,75	70,27
Control	19,40 A	0,73 A	3,99 A	26,61 A	66,88 A
1	18,00 B	0,61 A	4,14 A	29,99 A	48,85 B
2	18,20 B	0,58 A	4,11 A	31,64 A	47,19 B
3	17,60 B	0,53 B	4,15 A	34,35 A	51,06 B
4	16,80 B	0,61 A	4,02 A	27,25 A	50,78 B
5	16,60 B	0,60 A	4,03 A	27,75 A	48,30 B
Mean	17,76	0,61	4,07	29,60	52,17
LSD	1,11	0,15	0,15	9,85	10,50

Means with the same letter to control in the column do not differ at the level of 5% of probability by the test of Dunnett.

CONCLUSIONS

Regardless of the drop height, the mango 'Ubá' fruits present external and internal lesions when submitted to free fall. Drop heights between three and five meters cause serious external lesions to fruit and result in a disposal of about 16 to 40% of the fruits. From 1 m of drop height, over 60% of fruits revealed internal injuries, which depreciate quality of the fruits, with reduction in the contents of soluble solids and vitamin C.

REFERENCES

ALVES, E.O.; STEFFENS, C.A.; AMARANTE, C.V.T.; HENDGES, M.V.; ZANARDI, O.Z.; MIQUELOTO, A.; SILVEIRA, J.P.G.; BRACKMANN, A. Ripening of 'bruno' kiwifruits sumitted to impact mechanical injury treatment with 1 – methylcyclopropene. **Bragantia**, Campinas, v.69, n.3, p.753-758, 2010.

BASSAN, M.M.; MOURÃO FILHO, F.A.A.; ALVES, R.F.; BEZERRA, D.F.; COUTO, H.T.Z.; JACOMINO, A.P. Beneficiamento pós-colheita de lima ácida 'Tahiti' afeta sua qualidade e conservação. **Ciência Rural**, Santa Maria, v.46, n.1, p.184-190, 2016.

BENEVIDES, S.D.; RAMOS, A.M.; STRINGHETA, P.C.; CASTRO, V.C. Quality of the fruits and pulp of Ubá mango. **Ciência e Tecnologia de Alimentos**, Campinas, v.28, n. 3, p.571-578, 2008.

BLASCO, J.; ALEIXOS, N.; MALTÓ, E. Machine vision system for automatic quality grading of fruit. **Biosystems Engineering**, Harpenden, v.85, n.3, p.415-423, 2003.

CAMARGO, G.G.T.; FERREIRA, M.D.; ANDREUCETTI, C. Impact tests in fresh market tomatoes (*Lycopersicon esculentum* Mill.) cv Débora. **Horticultura Brasileira**, Brasília, DF, v.22, n.2, 2004. CD – ROM.

CARDELLO , H.M.A.B.; CARDELLO, L. Vitamin c, ascorbate oxidase activity and sensory profile of mango (*Mangífera índica*, L.), var. Haden during ripening. **Ciência e Tecnologia de Alimentos**, Campinas, v.18, n.2, p.211-217, 1998.

CEAGESP. Programa Brasileiro para a Modernização da Horticultura. **Normas de classificação de manga.** São Paulo: Centro de Qualidade em Horticultura, 2004. p.6.

CHITARRA, M.I.F.; CHITARRA, A.B. **Pós-colheita de frutas e hortaliças**: fisiologia e manuseio. 2. ed. Lavras: UFLA, 2005. 783p.

COUTINHO, E.F.; MALGARIM, M.B.; SOUZA, E.L.de; TREPTOW, R.de.O. Postharvest quality of pear (*Pyrus communis* L.) cv. Carrick submitted to diferents storage conditions. **Revista Brasileira de Fruticultura**, Jaboticabal, v.25, n.3, p.417-420. 2003.

DURIGAN, M.F.B.; MATTIUZ, B-H; DURIGAN, J.F. Mechanical injuries on post harvest quality of ‘Tahiti’ lime stored under enviromental conditions. **Revista Brasileira de Fruticultura**, Jaboticabal, v.27, n.3, p.369-372. 2005.

FONTES, V.L., MOURA, M.A.; VIEIRA, G.; FINGER, F.L. Plastic film and storage temperature effect in maintaining the lychee pericarp color (*Litchi chinensis*). **Revista Brasileira de Armazenamento**, Viçosa, MG, v.24, n.1, p.56-59, 1999.

GODOY, A.E.de; JACOMINO, A.P.; CERQUEIRA – PEREIRA, E.C.; GUTIERREZ, A.S.D.; VIEIRA, C.E.M.; FORATO, L.A. Mechanical injuries and the effects on the quality of golden papaya fruits. **Revista Brasileira de Fruticultura**, Jaboticabal, v.32, n.3, p.682-691, 2010.

HENDGES, M.V.; STEFFENS, C.A.; ANTONIOLLI, L.R.; AMARANTE, C.V.T.; ZANARDI, O.Z. Quality of apples ‘Fuji Suprema’ subject to different mechanical damages. **Revista Brasileira de Fruticultura**, Jaboticabal, v.33, n.2, p.671-675, 2011.

INSTITUTO ADOLFO LUTZ. **Métodos físico-químicos para análises de alimentos.** 4 ed. São Paulo, 2008. p.1020.

IBRAF - Instituto Brasileiro De Frutas. **Estatísticas**. Disponível em: <http://www.ibraf.org.br/estatisticas>. Acesso em: 02 dez. 2011.

KASAT, G.F.; MATTIUZ, B-H.; OGASSAVARA, F.O.; BIANCO, M.S; MORGADO, C.M.A.; JUNIOR, L.C.C. Effect of mechanical injuries on ‘Aurora-1’ peaches. **Revista Brasileira de Fruticultura**, Jaboticabal, v.29, n.2, p.318-322. 2007.

KAYS, J.S. **Postharvest physiology of perishable plant products.** New York: Van Nostrand Reinhold, 1991. p.453.

MAIA, V.M.; SALOMÃO, L.C.C.; SIQUEIRA, D.L.; PUSCHMAN, R.; FILHO, V.J.G.M.; CECON, P.R. Physical and metabolic alterations in ‘Prata Anã’ banana induced by mechanical damage at room temperature. **Scientia Agricola**, Piracicaba, v.68, n.1, p.31-36, 2011.

MATA, G.M.S.C.; OLIVEIRA, D.S.; DELLA LUCIA, C.M.; CAMPOS, F.M.; QUEIROZ, J.H.; PINHEIRO – SANT’ANA, H.M. β-carotene and vitamin C content during maturation of “UBÁ” mango (*Mangifera indica* L. var. Ubá). **Revista Instituto Adolfo Lutz**, São Paulo, v.70, n.2, p. 225-229, 2011.

MATTIUZ, B-H.; DURIGAN, J.F. Effect of mechanical injuries on respiratory process and chemicals parameters of ‘Paluma’ and ‘Pedro Sato’ guavas. **Revista Brasileira de Fruticultura**, Jaboticabal, v.23, n.2, p.282-287. 2001.

MATTIUZ, B-H.; BISCEGLI, C.I.; DURIGAN, J.F. Applications of the nuclear magnetic resonance tomography as a non-destructive method to evaluate the effects of mechanical injuries in 'Paluma' and 'Pedro Sato' guavas. **Revista Brasileira de Fruticultura**, Jaboticabal, v.24, n.3, p. 641-643, 2002.

MIRANDA, M.; SPRICIGO, P.C.; FERREIRA, M.D. Mechanical damage during harvest and loading affect orange postharvest quality. **Journal of the Brazilian Association of Agricultural Engineering**, Jaboticabal, v.35, n.1, p.154-162, 2015.

MORETTI, C.L.; SARGENT, S.A.; HUBER, D.J.; CALBO, A.G.; PUSCHMANN, R. Chemical composition and physical properties of pericarp, locule, and placental tissues of tomatoes with internal bruising. **Journal of the American Society for Horticultural Science**, Alexandria, v.123, n.4, p.656-660, 1998.

MONTERO, C.R.S.; SCHWARZ, L.L.; SANTOS, L.C. dos; ANDREAZZA, C.S.; KECHINSKI, C.P.; BENDER, R.J. Postharvest mechanical damage affects fruit quality of 'Montenegrina' and 'Rainha' tangerines. **Pesquisa Agropecuária Brasileira**, Brasília, DF, v.44, n.12, 2009.

PACHECO, A.L.V.; BORGES, K.S.; VIEIRA, G.; FREITAS, G.B. de. Quality of organic and conventional mango 'Ubá' offered at an agribusiness in the region of Zona da Mata of Minas Gerais. **Revista Brasileira de Agropecuária Sustentável**, Viçosa, MG, v.5, n.1, p.130 - 136, 2015.

QUINTANA, M.E.G.; PAULL, R.E. Mechanical injury during postharvest of 'Solo' papaya fruit. **Journal of the American Society for Horticultural Science**, Alexandria, v.118, n.5, p.618-622, 1993.

SAEG. **Sistema para análises estatísticas.** Versão 9.1. Viçosa: Fundação Arthur Bernardes, 2007.

SANCHES, J.; DURIGAN, J.F.; DURIGAN, M.F.B. Application of mechanical damages in avocados and their effects to the quality of the fruits. **Engenharia Agrícola**, Jaboticabal, v.28, n.1, p.164-175, 2008.

SILVA, D.F.P. da; SIQUEIRA, D.L. de; PEREIRA, C.S.; SALOMÃO, L.C.C.; STRUIVING, T.B. Characterization of fruits of fifteen mango varieties in the Zona da Mata region, Minas Gerais, Brazil. **Revista Ceres**, Viçosa, MG, v.56, n.6, p.783-789, 2009.

STEFFENS, C.A.; ESPÍNDOLA, B.P.; AMARANTE, C.V.T.; SILVEIRA, J.P.G.; CHECHI, R.; BRACKMANN, A. Respiration, ethylene production and quality of 'Gala' apples in function to impact injury and treatment with 1-methylcyclopropene. **Ciência Rural**, Santa Maria, v.38, n.7, p.1864-1870, 2008.

WADE, N.L.; BAIN, J.M. Physiological and anatomical studies of surface pittung of sweet cherry fruit in relation to bruising, chemical treatments and storage conditions. **Journal of Horticultural Science**, Kent, v.55, n.4, p.375-384, 1980.