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MECHANICAL INJURIES ON FIRMNESS OF 'DEBORAH' TOMATO STORED UNDER ENVIRONMENT CONDITION

ALESSANDRA ROSA DA SILVA[1], DANIELLA MOREIRA PINTO[2], PATRÍCIA MONIQUE CRIVELARI-COSTA[3], RODRIGO ESAÚ VASSOLER SILVA[4], LUIZ JOSÉ RODRIGUES[5]

[1]Departamento de Alimentos e Nutrição, Faculdade de Nutrição, Universidade Federal de Mato Grosso - UFMT, R. Quarenta e Nove, 2367, Boa Esperança, 78060-900, Cuiabá, Mato Grosso, Brasil, ale.rosa27@gmail.com
[2]Departamento de Engenharia de Alimentos, Centro Universitário de Várzea Grande – UNIVAG, Av. Dom Orlando Chaves, 2655, Cristo Rei, 78118-000, Várzea Grande, Mato Grosso, Brasil, daniella25@bol.com.br
[3]Departamento de Agronomia, Universidade do Estado do Mato Grosso – UNEMAT, Campus Alta Floresta, Av. Perimetral Rogério Silva - Norte 2, 78580-000, Alta Floresta, Mato Grosso, Brasil, costa.patricia@unemat.br
[4]Departamento de Agricultura Tropical, Universidade Federal de Mato Grosso - UFMT, R. Quarenta e Nove, 2367, Boa Esperança, 78060-900, Cuiabá, Mato Grosso, Brasil, rodrigo_vassoler@hotmail.com
[5]Departamento de Alimentos e Nutrição, Faculdade de Nutrição, Universidade Federal de Mato Grosso - UFMT, R. Quarenta e Nove, 2367, Boa Esperança, 78060-900, Cuiabá, Mato Grosso, Brasil, rodrigues.lui3@uol.com.br

ABSTRACT: This study aimed to evaluate the effect of mechanical injuries on 'Deborah' tomato, stored under environmental conditions. The fruits were subjected to mechanical injuries by impact, with 1.2 m drop, compression, 3-kg weight for 15 min., and cutting, of 30 x 2 mm with a 1.1 mm stainless steel blade. They were packed in styrofoam containers and stored under environmental conditions (25±1 ºC and 80±5% RH) for 15 days. A completely randomized experimental design, two factors: injuries (control, impact, compression and cutting) and storage time (0, 3, 6, 9, 12, 15 days), was adopted. The variables analyzed were mass loss, firmness, polygalacturonase and pectinmethylesterase activity and total and soluble pectin. The mechanical injuries compromised the firmness of the 'Deborah' tomatoes stored under environment condition at 3.6 N. As a result, after 15 days, there was a loss of mass of up to 3.2%, an increase of soluble pectin, at 186.14 mg $100g^{-1}$, decrease in total pectin, to 595.13 mg $100g^{-1}$, and changes in the activities of the enzyme polygalacturonase, up to 418.57 µmol $g^{-1}min^{-1}$, and pectinmethylesterase, up to 126.3 µmol $g^{-1}min^{-1}$. The cut injury was the treatment that was most harmful to 'Deborah' tomatoes.

Keywords: *Lycopersicon esculentum,* postharvest quality, impact, compression, cut.

LESÕES MECÂNICAS NA FIRMEZA DO TOMATE 'DEBORAH' ARMAZENADO EM CONDIÇÕES AMBIENTE

RESUMO: O objetivo do estudo foi avaliar o efeito de lesões mecânicas no tomate 'Deborah', armazenado em condições ambiente. Os frutos foram submetidos a lesões mecânicas por impacto, com queda de altura de 1,2 m, compressão, com peso de 3 Kg por 15 min., e corte, de 30 x 2 mm com lâmina de inox de 1,1 mm. Eles foram acondicionados em recipientes de isopor e armazenados em condições ambiente (25±1 ºC e 80±5% UR) por 15 dias. O delineamento experimental foi a fatorial inteiramente casualizado, com dois fatores: lesões (controle, impacto, compressão e corte) e tempo de armazenamento (0, 3, 6, 9, 12, 15 dias). As variáveis analisadas foram perda de massa, firmeza, atividade de poligalacturonase e pectinmetilesterase e pectina total e solúvel. As lesões mecânicas comprometeram a firmeza dos tomates 'Deborah' armazenados em condições ambiente em 3,6 N. Como consequência, após 15 dias, houve perda de massa, de até 3,2%, aumento da pectina solúvel, em 186,14 mg $100g^{-1}$, diminuição da pectina total, para 595,13 mg $100g^{-1}$, e alterações nas atividades das enzimas poligalacturonase, em até 418,57 µmol g^{-1} min^{-1}, e pectinmetilesterase, para 126,3 µmol g^{-1} min^{-1}. A lesão por corte foi o tratamento mais prejudicial aos tomates 'Deborah'.

Palavras-chave: *Lycopersicon esculentum*, qualidade pós-colheita, impacto, compressão, corte.

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1 INTRODUCTION

Among the vegetables on the Brazilian market, tomatoes stand out due to their great economic importance and because they are the main fruit present on the Brazilians' table. In 2017, the global production of tomatoes totaled 130 Mt. With a production of 52.5 Mt, China was the largest producer, representing 31% of the world's production. Brazil occupies the ninth position with 2.5% of world production by producing 4.2 Mt of tomato (FOOD AND AGRICULTURE ORGANIZATION, 2019). According to a survey of agricultural production performed by Brazilian Institute of Geography and Statistics (IBGE), tomato production reached 4.3 Mt in 2018 (IBGE, 2019).

Global post-harvest losses of tomato are as high as 30-50%, but this can be much higher in developing countries, as it is the case of Brazil, due to improper handling procedures and lack of appropriate methods to prevent decay. Failure to achieve food security in most developing countries can be attributed to, among other factors, neglect of the post-harvest chain during transportation and marketing (WAHOME, 2019).

In Brazil, inadequate transport is one of the main problems in the commercialization of tomatoes fruits, since it occurs on highways with different types of pavements, in trucks of varying sizes and types and in inadequate packaging, which affects the ripening stage and exposes the fruits to mechanical damage, which can cause injuries (FERNANDES, 2016).

The mechanical injuries, that can be grouped in injury by impact, compression and cutting, increase the perishability of plant products, given the increased metabolic activity and repartitioning of enzymes and substrates, and it can result in darkening of the peel, loss of firmness and flavor development and extraneous odors, reducing its life and causing commercial devaluation (KADER, 2013; HEUVELINK, 2018).

Loss of firmness is related to pectin, since they are responsible for the structural rigidity of the fruit. Action of pectinase enzymes, mainly the polygalacturonase and pectinmethylesterase in ripe fruits, causes pectic substances solubilization (VILAS BOAS et al., 2014; LANDIM; BARBOSA; BARBOSA JÚNIOR, 2016). In this sense, this work aimed to evaluate the effect of mechanical injuries by impact, compression and cutting on firmness of the 'Deborah' tomato stored under environmental condition.

2 MATERIAL AND METHODS

The experiment was carried out in the Food Technology Laboratory of the Federal University of Mato Grosso, *Campus* Cuiabá, Mato Grosso State, Brazil. Tomatoes for *in natura* consumption, cultivar Deborah were purchased from local shops of Cuiabá city. Partially ripe and with absence of injuries fruits were selected. The fruits were carefully transported in cardboard boxes lined with paper to the Laboratory.

Then, they were washed with running water and neutral detergent. After that, they were immersed in a solution of 0.15% sodium hypochlorite for 15 min at 15 ºC. After the sanitization, three types of mechanical injuries were evaluated: impact, compression and cut.

In the impact injury, the fruits were dropped from a height of 1.20 m on to a solid, flat and rigid surface. Each fruit suffered two impacts, on opposite sides of its equatorial line. For compression, the fruits were placed on a flat surface and a 2.0 kg weight exerted a 15 min pressure on the vegetables. In the cutting injury, the fruits were submitted to two incisions of 30 mm in length and 2 mm in depth, carried out longitudinally on both sides of the fruit, the cut was made with duly sanitized steel blades while it was fixed in a wooden support.

The injured areas were marked, and the fruits were packed in Styrofoam trays and stored under ambient conditions (25$\pm$1 ºC and 80$\pm$5% RH). Analyses were performed every three days during a fifteen-day period (0, 3, 6, 9, 12 and 15 days). The variables analyzed were mass loss, firmness, polygalacturonase activity, pectinmethylesterase activity and total and soluble pectin.

The mass loss was determined by weighing the fruits on a semi-analytical scale, with a resolution of 1 mg, and the results were expressed in percentage, considering the

difference between the initial mass and that obtained in each interval of storage time (CELESTINO, 2010; CRIVELARI-COSTA et al., 2021).

The firmness was determined at three distinct points of the fruit with the aid of a Stable Micro System TA.XT plus model texturometer, with 5 mm diameter tip and penetration in the fruits at a speed of 1.5 mm s^{-1} (VILAS BOAS et al., 2014). The speed of the pre and post-test was 10 mm s^{-1}. The result was expressed in Newtons (N).

For enzymatic extraction, pericarp tissue was crushed in polytron with distilled water and cooled to 4 °C. The homogenate was filtered through fine tissue and the residue resuspended in cooled 1M NaCl. The pH 6.0 was adjusted with 1N NaOH and the new homogenate was incubated at 4 °C for one hour. New filtration through gauze was performed and it was centrifuged at 5000 rpm, for 30 min at 4 °C. The supernatant was filtered again through filter paper and it was used to determine the enzyme activity.

For the pectinmethylesterase activity (PME), 5 ml of the enzyme extract was added over 30 ml of 1% citric pectin in 0.2M NaCl. The pH 7.0 was maintained for 10 min with 0.01N NaOH. One unit of PME unit was defined as the amount of enzyme able to catalyze the demethylation of pectin corresponding to the consumption of 1µmol min^{-1} g^{-1} of NaOH, under the test conditions (VILAS BOAS et al., 2014).

In the same sense, the polygalacturonase activity (PG) was determined by incubating the enzymatic extract with polygalacturonic acid for three hours at 30ºC. The reducing sugars released after the enzyme activity ceased were determined. One unit of PG activity was defined as the amount of enzyme capable of catalyzing the formation of 1 µmol min^{-1} g^{-1} of reducing sugar, under the conditions of the assay (RESENDE et al., 2004; VILAS BOAS et al., 2014).

The pectin total and soluble were extracted according to the technique described by McCready and McColomb (1952), and their contents were determined spectrophotometrically to 520 nm, as described by Bitter and Muir (1973). The results were expressed as mg $100g^{-1}$ of galacturonic acid.

The experiment was conducted in a completely randomized design, in a factorial scheme composed of two factors, injuries (control, impact, compression and cutting) and storage time (0, 3, 6, 9, 12 and 15 days), with three replications. The experimental plot consisted of a Styrofoam packing containing two fruits.

Statistical analysis of the data was performed with *Sisvar* statistical software, 4.3 version (FERREIRA, 2011). The data were submitted to analysis of variance by the F-test and the means were compared by the Tukey test ($p < 5\%$). The polynomial regression models were selected based on the significance of the F-test and the coefficient of determination.

3 RESULTS AND DISCUSSION

The mass loss and polygalacturonase activity in ‘Deborah’ tomatoes submitted to mechanical injuries stored under environment condition up to 15 days are presented in Table 1.

Table 1. Mass loss and polygalacturonase activity values in 'Deborah' tomatoes submited to mechanical injuries stored under environment condition up to 15 days.

Stored (days)	Injuries			
	Control	Impact	Compress	Cut
	Mass loss (%)			
0	0.0±0,0a	0.0±0,0 a	0.0±0,0 a	0.0±0,0 a
3	0.38±0,01b	0.43±0,01a	0.45±0,01a	0.48±0,01a
6	0.63±0,02 c	0.77±0,01b	0.77±0,02b	0.96±0,02a
9	1.06±0,1c	1.16±0,03b	1.16±0,05 b	1.48±0,1a
12	1.89±0,2c	2.05±0,3b	2.06±0,1b	2.25±0,1a
15	2.83±0,2c	3.00±0,1b	2.98±0,2b	3.20±0,3a
	Polygalacturonase activity (μmol g^{-1} min^{-1})			
0	224.40±0,12a	225.30±0,2a	225.63±0,3a	225.20±0,5a
3	254.57±0,3a	255.47±0,6a	252.97±0,5a	257.30±0,2a
6	303.37±0,5b	302.50±0,7b	303.80±0,6b	318.60±0,5a
9	331.33±0,8b	335.03±0,5b	334.63±0,6b	356.57±0,7a
12	378.93±0,4b	386.97±0,6b	384.70±0,6b	399.60±0,6a
15	398.13±0,9b	406.67±0,8b	403.70±0,6b	418.57±0,6a

Means followed by the same letter (horizontal) do not differ statistically from each other by Tukey test (p <5%).
Fonte: Elaborado pelos autores (2020).

The mass loss increased with storage, regardless of the type of injury held in 'Deborah' tomatoes. At the beginning of the storage, there was no difference between the treatments. On the 3rd day, control presented smaller values in relation to the injury's treatments, which did not differ among themselves (Table 1).

From the 6th day, the minor mass loss was observed in the control, followed by the impact and compression treatments, which showed statistically similar values, and the cut, which had the greatest mass loss, following this behavior until the end of the storage, at 15th day (Table 1).

The mechanical injuries often impair the barriers that prevent water loss, and this damage is one of the main causes of loss of postharvest quality, and it results in immediate reduction of the mass of the fruit (GODOY et al., 2010). Still, the loss of mass due to the respiratory process, which occurs mainly by perspiration, leads to the softening of the tissues of the tomato fruits, making them more susceptible to deteriorations and changes in appearance and flavor, especially, decreasing the product's commercial acceptability (HEUVELINK, 2018).

According to Chitarra e Chitarra (2005), in general, losses of 3-6% are sufficient to cause a marked decline in the fruity quality, promoting losses in appearance. Therefore, the 'Deborah' tomatoes that suffered injuries by cut (3.2%) on the 15th day of storage could be considered the lower-quality product, followed by the impact (3.0%) and compression (2.98%) treatments.

Concordant results were observed by Durigan, Mattiuz and Durigan (2005), who evaluated the effect on Tahiti lime, in this work, it was found that the cut injury was the treatment that promoted greater mass loss during storage. On the other hand, Godoy et al. (2010) found that for Golden papaya, injuries caused by impact led to greater loss of mass, corresponding to 19% more than the control fruits.

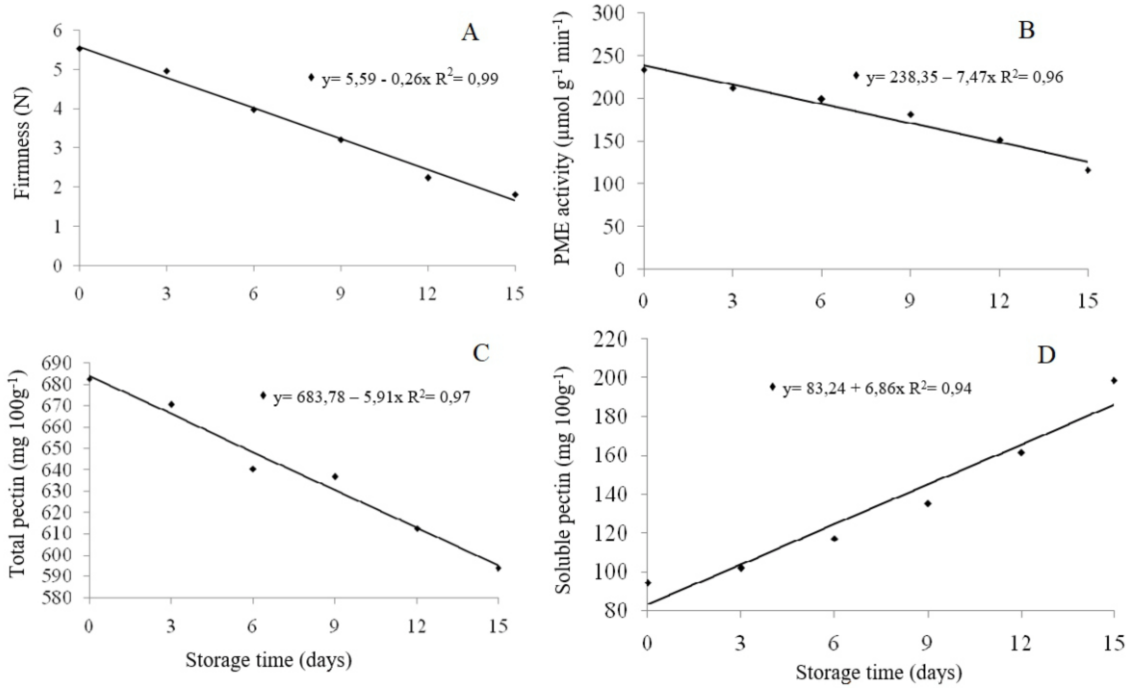
The polygalacturonase activity increased with storage in all treatments. The control and the mechanical injuries treatments had similar values until the 3rd day of storage. After the 6th day, the cut injury treatment showed greater value compared to the other treatments, which did not differ among themselves, following this trend until the end of the storage, at 15th day (Table 1).

The greatest value of polygalacturonase activity in the cut injury treatment can be attributed to the deep physical damage caused in the fruit, which promoted the rupture of their tissues and the consequent contact between enzymes, as the polygalacturonase, and substrates.

Among the various causes that result in losses, there are mechanical damages, which promote changes in the activation of enzymes, alterations in firmness, and increases on water loss (GODOY et al., 2010). Regarding the modifications in enzyme activation, polygalacturonase is one of the enzymes that showed the highest activity in the injured 'Deborah' tomatoes (VILAS BOAS et al., 2014). This is according with the results on this present work.

The firmness, pectinmethylesterase activity, total and soluble pectin values in 'Deborah' tomatoes submitted to mechanical injuries and stored under environment condition up to 15 days are presented in Figure 1.

Figure 1. Firmness (A), pectinmethylesterase activity (B), total pectin (C) and soluble pectin (D) values in 'Deborah' tomatoes stored under environment condition up to 15 days.



Fonte: Elaborado pelos autores (2020).

The firmness of 'Deborah' tomatoes was significantly affected by mechanical injuries, with the cut injury, that presented result of 3.53 N, showing smaller value in relation to the other treatments. The control, with 3.67 N, the impact injury, with 3.65 N, and the compression injury, with 3.64 N, were statistically similar. It can be observed that the firmness decreased with the course of storage, varying from 5.53 N, on the 3rd day, to 1.82 N, on the 15th day (Figure 1A).

Firmness is an important quality attribute for tomatoes for fresh consumption, as it indicates the tolerance of the fruit to handling during harvest, transportation and marketing (VILAS BOAS et al., 2014). The progressive loss of this variable during the ripening of tomatoes can be attributed to the reduction in the thickness of the cell walls and the cohesive force that holds them together, by depolymerizing pectin, for example.

In the same sense, the softening process, during fruit ripening, occurred due to changes in the enzymatic activity of the cell wall that, together with the loss of water, contributed to alterations in the fruit's texture (GODOY et al., 2010). The ripening of tomato fruits involves numerous metabolic steps, among which the increase in ethylene production, degradation of the epicarp and endocarp by the enzymes polygalacturonase and pectinamethylesterase, as well as the softening of the fruits by water

loss stand out (VILAS BOAS et al., 2014). Thus, it was possible to conclude that the mass loss was one of the factors responsible for the decrease in firmness.

There was a reduction in the amount of pectinmethylesterase activity to 233.14 µmol g^{-1} min^{-1}, on the first day, to 116.05 µmol g^{-1} min^{-1}, on the 15^{th} day during the storage of 'Deborah' tomatoes (Figure 1B). Vilas Boas et al. (2014) also observed the performance of this enzyme in hybrid tomatoes, with reduction in the activity of this enzyme with the fruit storage, crediting this behavior to the advanced maturation of the fruits, once the culmination of this enzyme action occurs in green stadiums of maturation. This possibly occurred in 'Deborah' tomatoes as well.

The values of total pectin suffered influence of the mechanical injuries, with the reduction of its content during storage, ranging from 682.44 mg 100 g^{-1}, initially, to 593.79 mg 100g^{-1}, at the end of the storage on 15^{th} day (Figure 1C). Instead, soluble pectin had their values increased with storage, from 94.13 mg 100g^{-1}, initially, to 198.73 mg 100 g^{-1} at 15^{th} day (Figure 1D).

The pectin's are polymers of galacturonic acid that play an important role in the cell wall as cement material, maintaining the cohesion between the cells. With the advancement of maturation, there is hydrolysis (breaks) and solubilization of pectin, contributing to the softening of the tissues (CHITARRA; CHITARRA, 2005). The trend during maturation and ripening of the fruit, it is the reduction in pectin content which occurs due to the increased content of soluble and pectin solubilization, causing the softness of the fruits (VILAS BOAS et al., 2014).

Finally, the fruits submitted by cut injury showed a greater loss of firmness when compared to the control fruits and the impact and compression injuries treatments, which does not differ statistically. The loss of firmness in the fruits, especially in cut injury treatment, it can be associated with increased values of mass loss, polygalacturonase activity and soluble pectin variables. As for the pectinmethylesterase activity and total pectin, theses variables were affected by the factor isolated storage, with a decrease in their values with the longest storage time, of 15 days.

4 CONCLUSIONS

The main mechanical injuries identified in 'Deborah' tomatoes are pressing, cutting and falling, and the largest percentage of these injuries is verified in the middle region of the fruits.

Mechanical injuries, regardless of type, compromised the firmness of 'Deborah' tomatoes stored under environmental conditions, causing loss of mass, increments in soluble pectin, decrease in total pectin and alterations in the activities of the enzymes polygalacturonase and pectinmethylesterase.

These injuries are responsible for significant losses in the quality of tomatoes, and those resulting from cut injuries are the ones that most contribute to the loss of quality, accelerating the ripening of the fruits, in addition to the greater loss of fresh mass due to the activity of the activity of the polygalacturonase enzyme.

5 REFERENCE

BITTER, T.; MUIR, H. M. A modified uronic acid carbazole reaction. **Analytical Biochemistry**, New York, v. 4, n. 4, p. 330-334, 1973. DOI: 10.1016/0003-2697(62)90095-7. Available from: https://www.sciencedirect.com/science/article/pii/0003269762900957. Accessed on: 08 may 2020.

CELESTINO, S. M. C. **Princípios de secagem de alimentos**. Planaltina: Embrapa Cerrados, 2010. 51 p.

CHITARRA, M. I. F.; CHITARRA, A. B. **Pós-colheita de frutas e hortaliças**: fisiologia e manuseio. Lavras: UFLA, 2005. 785 p.

CRIVELARI-COSTA, P. M.; BIANCHINI, A.; CANEPPELE, C.; AZEVEDO, P. H; SILVA, A. L. Drying kinetics of *Amaranthus cruentus* 'BRS Alegria' seeds in natural and artificial methods. **Brazilian Journal of Agricultural and Environmental Engineering**, Campina Grande, v. 25, n. 5, p. 345-352, 2021. DOI: 10.1590/1807-1929/agriambi.v25n5p345-352. Available from: https://www.scielo.br/j/rbeaa/a/8bNjXqLrhGcqQjPnrxfnVtq/?lang=en. Accessed on: 11 jul. 2021.

DURIGAN, M. F. B.; MATTIUZ, B.; DURIGAN, J. F. Mechanical injuries on post harvest quality of 'Tahiti' lime stored under enviromental conditions. **Revista Brasileira de Fruticultura**, São Paulo, v. 27, n. 3, p. 369-372, 2005. DOI: 10.1590/S0100-29452005000300008. Available from: https://www.scielo.br/j/rbf/a/r8DX7tvwKtghrLKXmWrMWGs/?lang=pt. Accessed on: 09 may 2020.

FERNANDES, L. S. **Qualidade pós-colheita de tomates submetidos à esforços de compressão e vibrações mecânicas**. 2016. Tese (Doutorado em Engenharia Agrícola) – Universidade Federal de Viçosa, Viçosa, MG, 2016.

FERREIRA, D. F. Sisvar: a computer statistical analysis system. **Ciência e Agrotecnologia,** Lavras, v. 35, n. 6, p. 1039-1042, 2011. DOI: 10.1590/S1413-70542011000600001. Available from: http://dx.doi.org/10.1590/S1413-70542011000600001. Accessed on: 08 may 2020.

FOOD AND AGRICULTURE ORGANIZATION. **FAO Statistical Yearbook**. Rome: FAO, 2019.

GODOY, A. E.; JACOMINO, A. P.; CERQUEIRA-PEREIRA, E. C.; GUTIERREZ, A. S. D.; VIEIRA, C. E. M.; FORATO, L. A. Injúrias mecânicas e seus efeitos na qualidade de mamões Golden. **Revista Brasileira de Fruticultura**, Jaboticabal, v. 32, n. 3, p. 682-691, 2010. Available from: https://www.scielo.br/pdf/rbf/v32n3/aop09210. Accessed on: 09 may 2020.

HEUVELINK, E. **Tomatoes**. 2. ed. Wageningen: CABI, 2018.

IBGE. **Indicadores IBGE**: Levantamento Sistemático da Produção Agrícola – Table 2, 5 – Área, produção e rendimento médio confronto entre as estimativas 3º prognóstico/Janeiro Brasil. [*S. l.*]: IBGE, 2019. Available from: https://biblioteca.ibge.gov.br/visualizacao/periodicos/2415/epag_2019_jan.pdf. Accessed on: 20 sep. 2019.

KADER, A. A. Postharvest Technology of Horticultural Crops - An Overview from Farm to Fork. **Ethiopian Journal of Science and Technology**, Bahir Dar, v. 1, n. 1, p. 1-8, 2013. Available from: https://ucanr.edu/sites/Postharvest_Technology_Center_/files/231724.pdf. Accessed on: 08 may 2020.

LANDIM, A. P. M.; BARBOSA, M. I. M. J.; BARBOSA JÚNIOR, J. L. Influence of osmotic dehydration on bioactive compounds, antioxidant capacity, color and texture of fruits and vegetables: a review. **Ciência Rural**, Santa Maria, v. 46, n. 10, p. 1714-1722, 2016. DOI: 10.1590/0103-8478cr20150534. Available from: https://doi.org/10.1590/0103-8478cr20150534. Accessed on: 08 may 2020.

McCREADY, P. M.; McCOMB, E. A. Extraction and determination of total pectic material in fruits. **Analytical Chemistry**, New York, v. 24, n. 12, p. 1986-1988, 1952. DOI: 10.1021/ac60072a033. Available from: https://doi.org/10.1021/ac60072a033. Accessed on: 08 may 2020.

RESENDE, J. M.; CHITARRA, M. I. F.; MALUF, W. R.; CHITARRA, A. B.; SAGGIN JÚNIOR, O. J. Activity of the enzymes pectinmetylesterase and polygalacturonase during the ripening of

tomatoes of the multilocular group. **Horticultura Brasileira**, Brasília, DF, v. 22, n. 2, p. 206-212, 2004. DOI: 10.1590/S0102-05362004000200009. Available from: https://doi.org/10.1590/S0102-05362004000200009. Accessed on: 08 may 2020.

VILAS BOAS, A. A. C. **Qualidade pós-colheita de frutos de tomateiro em função de fontes de cálcio**. 2014. Dissertação (Mestrado em Produção de Plantas) – Universidade Federal de Lavras, Lavras, 2014.

WAHOME, P. K. The management of post-harvest losses of tomato in developing countries. **UNISWA Journal of Agriculture**, Kwaluseni, v. 20, n. 1, p. 34-40, 2019. Available from: http://ojs.uneswa.ac.sz/index.php/uja/article/view/425. Accessed on: 08 may 2020.