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DIAGNOSIS OF MECHANICAL INJURIES IN AVOCADOS BY MAGNETIC RESONANCE IMAGING

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SUMMARY

It was aimed at to determine the potential of magnetic resonance imaging use, as non-destructive method, to evaluate the effects of the mechanical injuries in avocados. Matures fruits were used, of 'Quintal' cultivating, and the injuries were submitted by two impacts, in opposed sides of the fruit provoked by free fall from 2.00 m. In the compression injury, they were submitted by a weight of 117.6 N, for 24 hours and in the cut injury, they received four longitudinal lesions in opposed sides, with 40.0 length mm and 4.0 depth mm. The injured fruits were stored under atmosphere conditions (22 ± 2 °C and 50% UR) and analyzed in magnetic resonance imaging Varian Inova of 2 Tesla, every 5 days, being obtained symmetrical imaging starting from the center of the fruit. The tomography of magnetic resonance was shown as an effective tool in the detection of internal injuries in avocado fruits. The fruits submitted to the injuries by compression and impact didn't show external lesions, but the images indicated the occurrence of the internal lesions and the evolution of the same ones during the ripening. For impact, the fruits also presented cracks in the pulp adjacent to the pit, which they were filled out by vegetable tissue in 6 days of storage. The cut injury provoked superficial deformations, whose internal effects were also shown in the imaging's, which presented a cicatrisation process during the storage period.

Key Words: *Persea americana,* postharvest, mechanical injuries, magnetic resonance imaging.

INTRODUCTION

Now, the production of fruits with high quality aiming at to assist markets every time demanding has been the tonic of the Brazilian horticulture. That is due to the export possibility and the cultural changes in the alimentary habits of the Brazilian, especially, in the middle class and high average populations (Souza, 2001).

For these demands to be appropriately satisfied, the fruits should be appraised individually through techniques safe, fast and non-destructive as for their physical attributes (Thomas et al., 1995; Clark et al., 1997).

The Magnetic Resonance Spectroscopy (MRS) it is a safe and capable method of supplying information on the chemical and physical state of the materials, as well as about the physiologic state and the metabolic conditions of biological systems, without any extraction or destruction of the sample (Bottomley, 1982; Clark et al., 1997).

The fundamental condition to analyze some material for MRS is the presence of nuclei with magnetic moment. In the case of fruits, the most suitable nucleus is the hydrogen, which results in high value in the relationship signal /noise due to abundance and, consequently, it allows the obtaining of spectra and images relatively in times short. The mobility and the concentration of those nuclei of hydrogen vary with the metabolic processes and the maturation of the fruits and the concentration of the same ones can be associated with their qualitative attributes, as the occurrence of mechanical injuries (Chen et al., 1996).

Being considered that the parameters of the magnetic resonance of the water in foods are dependent of their cellular architecture, the changes that they affect this structure can be detected through the tomography by magnetic resonance with the formation of images (Magnetic Resonance Imaging, MRI) (Nascimento et al., 1999; Biscegli et al., 2000).

Preliminary studies, accomplished by Chen et al. (1989), they indicate MRI as powerful tool to supply information on the internal structure of whole fruits, allowing the determination of the maturation stadium and of the occurrence of mechanical injuries, dehydrated areas, damages for larvae and internal softening. Many authors have been using this tool as non-destructive method, to evaluate the quality of fresh fruits (Hall et al., 1998; Zion, et al., 1995; Gonzales et al., 2001, Mattiuz et al, 2002).

Darkened areas were detected, through MRI, in apples 'Braeburn' during the storage in atmosphere controlled under high concentrations of CO_2 (Clark & Burmeister, 1999). That technique also allowed the detection of internal disturbances in pears (Wang & Wang, 1989), internal browning in apples (Wang et al., 1988; Gonzalez et al., 2001), textural characteristics in nectarines (Sonego et al., 1995), changes in the texture in melons (Hall et al., 1998) and mechanical injuries in guavas (Mattiuz et al, 2002).

This work aimed at to determine the potential of the use of the tomography of magnetic resonance, through the software of processing of images SIARCS", as non-destructive method, to evaluate the effects of the mechanical injuries in 'Quintal' avocados.

MATERIAL AND METHODS

Avocado tree fruits were used of cultivating 'Quintal", that immediately after the crop they were transported carefully to the Laboratory of Technology of FCAV/UNESP - Jaboticabal, SP, Brazil. The fruits were picked at the mature stadium, in other words, in the commercialization point. After immersion in cold water (15 °C) chlorinated (150 mg of cloro.L^{-1}), for five minutes, and rest for 1 hour, the fruits were submitted to the mechanical injuries.

Besides the fruits that didn't suffer any lesion type (controls), there were the ones that received the injuries, in a total of 4 repetitions for treatment. For the impact, they were dropped, in free fall, of a height of 2.00 m. Each fruit suffered two impacts, in opposed sides, in their equatorial areas. For the compression injury, they were put under a weight of 117.6 N, for 24 hours, provoking 2 opposite lesions, in the longitudinal sense of the fruits. The cuts injuries was gotten being applied four longitudinal cuts, with 40 length mm and 4 depth mm, to the opposed sides of the fruits. The injured areas were demarcated and the fruits were transported, carefully, until EMBRAPA Agricultural Instrumentation, in São Carlos, SP, Brazil, where they were stored 22 ± 2 °C and 50% UR.

The fruits were analyzed every five days in nuclear magnetic resonance tomography Varian Innovates of 2 Tesla, inserting them in the reel of radiofrequency of the type "cage" with internal diameter of 14.0 cm, operating in the frequency of 85.53 MHz. The images were obtained starting from the detection of the protons of hydrogen (^1H), essentially the one of the molecules of water that composes the fruits. The generated images are at head offices of 256 x 256 *pixels*, in 256 ash tones, and in slices, with 2.0 mm of thickness, spaced of 5.0 mm. For each fruit was obtained symmetrical images starting from the center of the fruit, in sagittal cuts for submitted them to the cuts and coronals for the control and submitted them to the impacts and the compression. The bidimensionals images were analyzed regarding form, location and texture of the ash degrees, and indicate the situations of the movable water (free) or more linked to the healthy tissues.

RESULTS AND DISCUSSION

In the Illustration 1 the images are presented obtained by tomography of nuclear resonance of the avocado 'Quintal' injured or not. The obtained images are observed starting from the signs of the nuclei of H of the water, that it corresponds the at least 93% of the intensity of the spectrum of H in avocado fruits.

In the fruits of the control (Illustrations 1A and 1B) the decrease in the molecular mass implicated in increase in the mobility of the molecules of water, providing increase in the time of relaxation spin-spin (*T2*), and resulting in images with clearer shade. Those clearer areas became more evident with the storage (6th day). Probably the answer indicates increase in the concentration of sugars, due to hydrolyze of reservation's carbohydrate and to the collapse of the cellular head office, due to the ripening (Hall et al., 1998).

On the other hand, the clearest areas are also to indicate the condition of movable water (free) caused by the injuries of mechanical nature. In the compression injury visible external symptom and the pericarp of the fruit was not observed was shown seemingly intact after the injury (Illustration 1C). The physical stress caused by the compression produced increase in the amount of freer liquids, which it was only visible after 6 days (Illustration 1 D) and it is indicated by the whitish areas of the mesocarp and marked by circles. These lesions didn't present external correspondence. The injured areas are as whiter the more close of the peel of the fruits. The structure and the cellular elasticity of the pulp of the avocado checked mechanical resistance to the compression, doing with that the internal tissues were preserved, in function of their reologicals properties (Mohsenin, 1986).

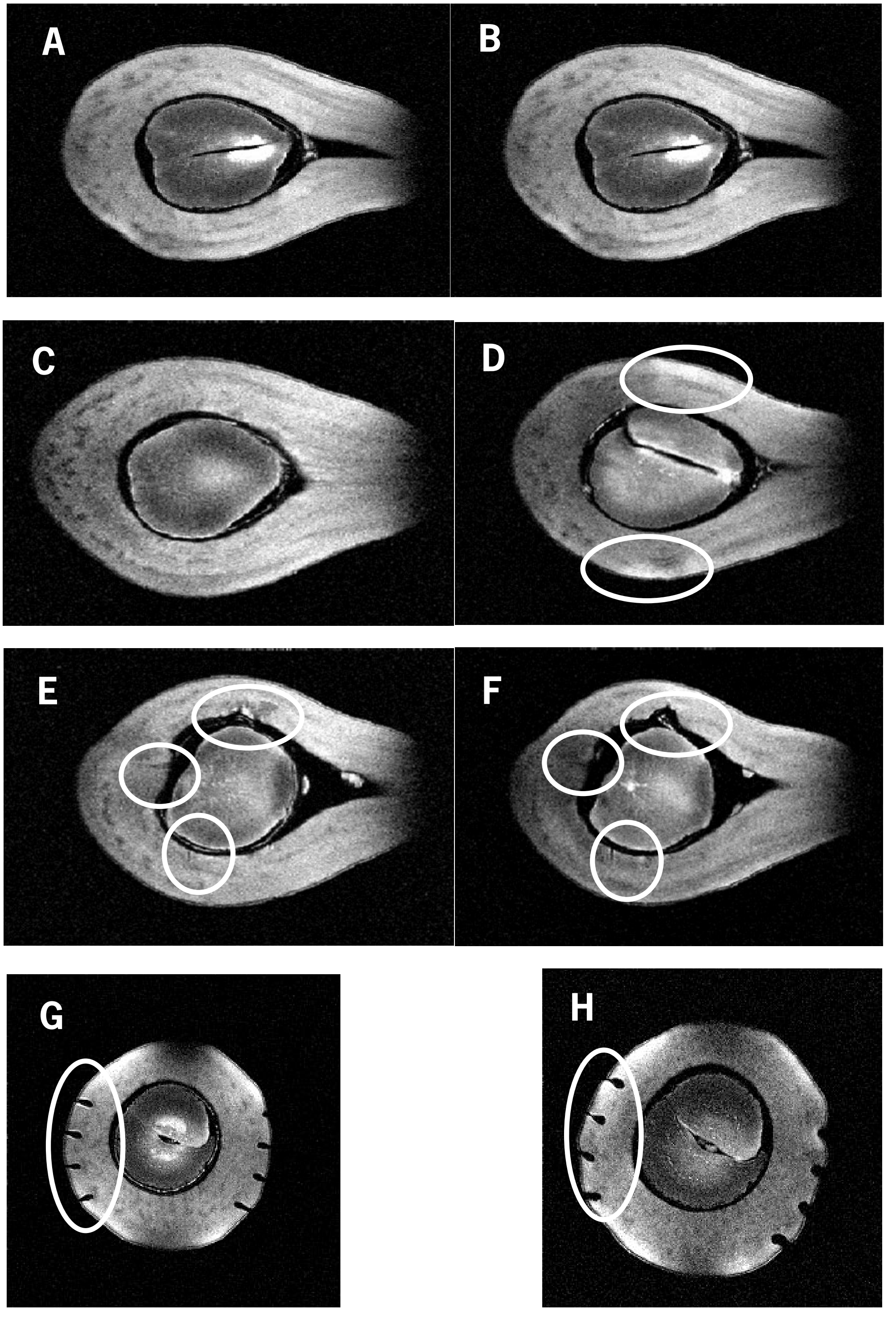

Illustration 1. Magnetic resonance imaging of avocado 'Quintal' submitted to three types of injuries. (A) Coronal cut of the fruit controls, in the 1° day, and (B) after 6 days of storage; (C) coronal cut of the fruit submitted to the compression in the 1° day and (D) after 6 days; (E) coronal cut of the fruit submitted to the impacts, in the 1° day and (F) after 6 days; (G) sagittal cut of the fruit submitted to the cuts, in the 1° day and (H) after 6 days.

In the injury for impact the avocados didn't present external symptoms even after the storage for 6 days, but, internally, they presented fissures, in the close pulp to the pit, suitable for the circles in the Illustration 1E. As the fruits went maturing these fissures increased, but at the same time, the pit produced tissue to fill out those spaces and to inhibit his progress for the rest of the pulp, according to the suitable in the Illustration 1F. Moretti (2000) it verified drastic reduction in the quality of tomatoes injured by impact, what was not observed for the avocado that was shown resistant that injury.

The injuries for cuts, that they showed very clearing in the surface of the fruits, presented as darkness lines in the pulp, in the images (Illustration 1G and 1H). The whitish areas, close to the peel, they are workmanships caused by the size of the fruit of this to cultivate that he approached the useful limit of the radio-frequency reel. In the 6th day of evaluation, the injured area totally came filled out by healing material, due to the lignification of the tissues and visualized through scanning electron microscope (SEM), where the production of this tissue can be verified at the place injured*. This was not it observed in injured guavas by cuts, there was accentuated loss of fresh mass in the place of the injury, causing reduction in the surface and creating concave lesions in the injured places (Mattiuz et al., 2002).

CONCLUSIONS

The tomography of magnetic resonance showed to be an effective tool in the detection of internal injuries of avocado fruits. The fruits submitted to injures by compression and impact in spite of they show not external lesions, their images indicated the occurrence of injury internal and the evolution of the same during the ripening. In the injury for impact, the fruits also presented cracks in the close pulp of the pit, which they were filled out by tissue of the vegetable in 6 days of storage. The injury for cut provoked superficial deformations and submitted a cicatrisation process by completion of the lesions with woven lignification.

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