Comparison of X-ray Computer Tomography and Magnetic Resonance Imaging for Detection of Pest Infestation in Prunus Persica

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1. Introduction

Non-destructive testing (NDT) technology has been developed for a long time to increase inspection speed, efficiency, and accuracy. As a result, various methods of NDT technology have become a standard inspection method. NDT technology is widely used to inspect the internal structure of agricultural food products due to the sample non-destructiveness during the inspection and relatively very straightforward sample preparation process compared to other internal structure inspection methods [1, 2].

In particular, NDT technology is used to investigate the internal structure of fruits and vegetables damaged by pests, in which marketability is very low. Furthermore, when foreign pests are introduced during the import process, a bigger problem may occur. Fruits and vegetables damaged by pests were hard to sort through the external inspection method. However, NDT technology has very advantageous in this hidden structure inspection situation [3].

Herein, pests damaged Prunus persica was inspected by X-ray computed tomography (X-ray CT) and magnetic resonance imaging (MRI), focusing on the deformation of the internal structure. Moreover, we also artificially set the condition where the pest is in the Prunus persica. We investigated the feasibility of inspecting the internal structure deformation of Prunus persica using NDT technology. The quantitative evaluation was not performed at the moment. This study demonstrated that the internal structure of Prunus persica damaged by pests can be inspected using NDT technology.

2. Materials and Methods

2.1 Prunus persica

Prunus persica was harvested on July 10 in 2020. Prunus persica damaged by pests was refrigerated to prevent over-ripening. To assume that the condition was pest located inside the Prunus persica, a Tenebrio Molitor larva was inserted through a hole made by pest infestation. Larva inserted Prunus persica was inspected by X-ray CT and MRI.

2.2 X-ray CT scans

X-ray CT scan was performed by using the CT component of nanoScan PET/CT (Mediso Ltd., Hungary) in the Korea Research Institute of Bioscience and Biotechnology (KRIBB). The X-ray tube voltage was 50 kVp, and the scan time was 300 s. The voxel size was 228.4 μm × 228.4 μm × 228.4 μm. Each X-ray CT image consisted of a 486 × 486 matrix sizes and was reconstructed into 359 slices.

2.3 MRI scans

MRI scan was performed by using various MRI systems in the Korea Basic Science Institute (KBSI). In the case of MRI, there is a clear difference in image quality depending on the magnetic field strength. In this study, Prunus persica was inspected using 3.0, 7.0, and 9.4 T MRI to confirm the difference in image quality according to magnetic field strength. The MRI systems used for the MRI scan are as follows. Philips Achieva 3.0 T TX (Philips Healthcare, The Netherlands), Philips Achieva 7.0 T (Philips Healthcare, The Netherlands), and the Varian MRI System 9.4 T (Varian Inc., USA). MRI scan parameters are given in Table I.

Table I: MRI scan parameters

	Image types	Matrix sizes	Slice thickness
3.0 T	T_1-weighted	256 × 256	0.8 mm
7.0 T	T_1-weighted	288 × 288	0.7 mm
9.4 T	T_1-weighted	256 × 256	0.5 mm

3. Results and Discussion

3.1 X-ray CT inspection

X-ray CT and MRI images were analyzed using Computational Environment for Radiological Research (CERR) [4] which was MATLAB based software (MATLAB 2020a; MathWorks Inc., USA) and ImageJ (v1.53a National Institutes of Health, USA) [5]. Fig. 1 shows the Prunus persica X-ray CT image. The internal structure of Prunus persica damaged by pests was confirmed through an X-ray CT image. The difference between the sound flesh part and the part damaged by pests was distinguished. However, the contrast between Tenebrio Molitor's larva and Prunus persica's flesh was not clear.

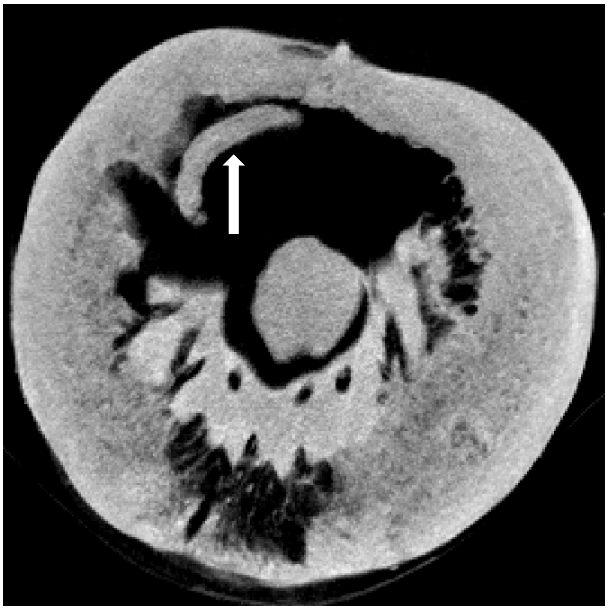

Fig. 1. Prunus persica X-ray CT image. The white arrow indicates a Tenebrio Molitor larva.

The contrast is insufficient to check whether or not pests have infested into the fruit at the actual quarantine site. To perform more efficient NDT inspection using X-ray CT, it seems necessary to optimize scan parameters and improve detector performance. In this study, the CT component in the PET/CT, which has lower performance than general X-ray CT, was used. If micro CT is used in the future, better inspection results would be obtained.

3.2 MRI inspection

Fig. 2 shows the Prunus persica MRI images. Similar to the X-ray CT image, the internal structure of Prunus persica damaged by pests was confirmed through MRI images. MRI images were acquired with various magnetic field strengths, and the difference in image quality was clearly distinguished according to the magnetic field strength.

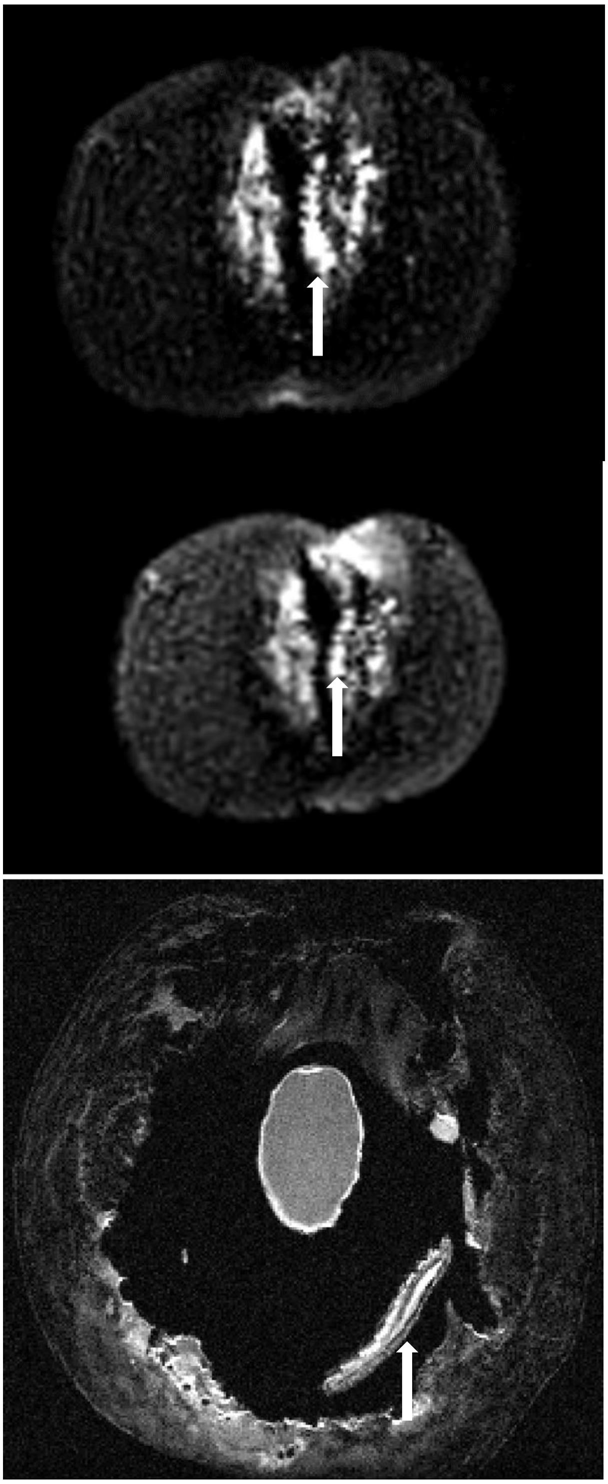

Fig. 2. Prunus persica MRI images. 3.0, 7.0, and 9.4 T T_1-weighted MRI images from top to bottom. The white arrows indicate a Tenebrio Molitor larva.

Naturally, the stronger the magnetic field strength, the better the contrast. However, in the case of MRI, the equipment is very expensive and takes a long time to shoot, so it is not suitable for use in the actual quarantine site. In other words, actual quarantine NDT inspection using X-ray CT is more realistic, and MRI will be a method for more detailed NDT inspection.

4. Conclusions

In this study, we investigated the feasibility of inspecting the internal structure of Prunus persica using X-ray CT and MRI. Both methods were able to grasp the internal structure effectively. However, some aspects need improvement to be used for NDT inspection right now. As NDT inspection is currently very useful in many fields, if further improvements and optimizations are made, it can be used very effectively in the field of quarantine.

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REFERENCES

[1] Du. Z, Hu. Y, Ali Buttar. N, and Mahmood. A, X-Ray computed tomography for quality inspection of agricultural products: A review, Food Sciences and Nutrition, Vol. 7, p. 3146-3160, 2019.

[2] N. Ekramirad, A.A. Adedeji, and R. Alimardani, A review of non-destructive methods for detection of insect infestation in fruits and vegetables, Innovations in Food Research, Vol. 2, p. 6-12, 2016.

[3] L. Schoeman, P. Williams, A. du Plessis, and M. Manley, X-ray micro-computed tomography (μCT) for non-destructive characterisation of food microstructure, Trends Food Sci Technol, Vol. 47, p. 10-24, 2016.

[4] J.O Deasy, A.I. Blanco, and V.H. Clark, CERR: a computational environment for radiotherapy research, Med. Phys, Vol. 30, p.979-985, 2003.

[5] C.A. Schneider, W.S. Rasband, and K.W. Eliceiri, NIH Image to ImageJ: 25 years of image analysis, Nat. Methods, Vol. 9, p. 671-675, 2012.