Non-destructive Evaluation of Insect Infestation on Mango Fruit: Optimal Scan Time of X-ray Computed Tomography

Taeyun Kim [a,b], Jaegi Lee [a*], Gwang-Min Sun [a], Byung-Gun Park [a], Hae Jun Park [c], Deuk-Soo Choi [d], Sung-Joon Ye [b,e]
[a]*HANARO Utilization Division, Korea Atomic Energy Research Institute, 34057, Daejeon, Republic of Korea*
[b]*Program in Biomedical Radiation Sciences, Department of Transdisciplinary Studies, Graduate School of Convergence Science and Technology, Seoul National University, 08826, Seoul, Republic of Korea*
[c]*Radiation Utilization and Facilities Management Division, Korea Atomic Energy Research Institute, 56212, Jeongeup, Republic of Korea*
[d]*Plant Quarantine Technology Center, Animal and Plant Quarantine Agency, 39660, Gimcheon, Republic of Korea*
[e]*Advanced Institutes of Convergence Technology, Seoul National University, 16229, Suwon, Republic of Korea*

[*]*Corresponding author: jgl@kaeri.re.kr*

1. Introduction

Non-destructive testing (NDT) technology has been developed for a long time, such as X-ray computed tomography (CT) [1, 2]. As a result, NDT technology is widely investigated to inspect agricultural products. In particular, NDT technology is used to inspect the internal structure of agricultural products damaged by pests during quarantine process. The introduction of pests can cause significant damage to the agricultural environment. However, pest-infested agricultural products were hard to sort through the conventional external inspection method [3].

Herein, pest-infested Mangifera indica was inspected by CT. We artificially set the pest-infested condition. In particular, CT images were acquired with various scan times to analyze whether it was possible to determine pest infestation. One of the most critical issues in the quarantine process is a near real-time scan. Long inspection time is unsuitable for quarantine because vast amounts of agricultural products have to be tested. We investigated how short scan times can block pest-infested Mangifera indica in the quarantine process when performing NDT inspection using CT.

2. Materials and Methods

2.1 Mangifera indica

To assume that the pest-infested condition, chestnut weevils (Curculio sikkimensis) were inserted through a drilled hole. The pest-infested Mangifera indica was refrigerated to prevent over-ripening until CT images were acquired.

2.2 CT scans

An X-ray CT scan was performed by a Quantum GX2 micro-CT imaging system (PerkinElmer, USA). The pest-infested Mangifera indica was fixed on the sample bed. A PerkinElmer Quantum GX2 software was used for CT image reconstruction. CT images were reconstructed into 512 slices, with a voxel size of 172 μm. A built-in filter was used to reduce noise. Various scan times were selected to determine optimal scan time of CT images (Table 1).

Table 1. Scan time of CT images

Scan mode	Scan time
High-speed mode	3.9 seconds
	8 seconds
Standard-speed mode	18 seconds
	2 minutes
High-resolution mode	4 minutes
	14 minutes

3. Results and Discussion

3.1 CT inspection

CT images were analyzed using the PerkinElmer software. Fig. 1 shows the Mangifera indica CT image with various ranges of scan time. As expected, noise was clearly observed in CT images acquired with a short scan time. The noise gradually decreased as the scan time increased. In particular, the frass that chestnut weevil ate and discharged Mangifera indica seed clearly appeared in high-resolution mode but was significantly blurring in high-speed mode. The chestnut weevil, which is the most important thing from a quarantine point of view, was well identified at the whole scan time range. However, comparing the 3.9 sec and 14 min CT images revealed a significant difference in the detailed shape of the chestnut weevil. The longer the scan time, the more data was collected for image reconstruction. As a result, the CT image was acquired close to the actual shape of the chestnut weevil.

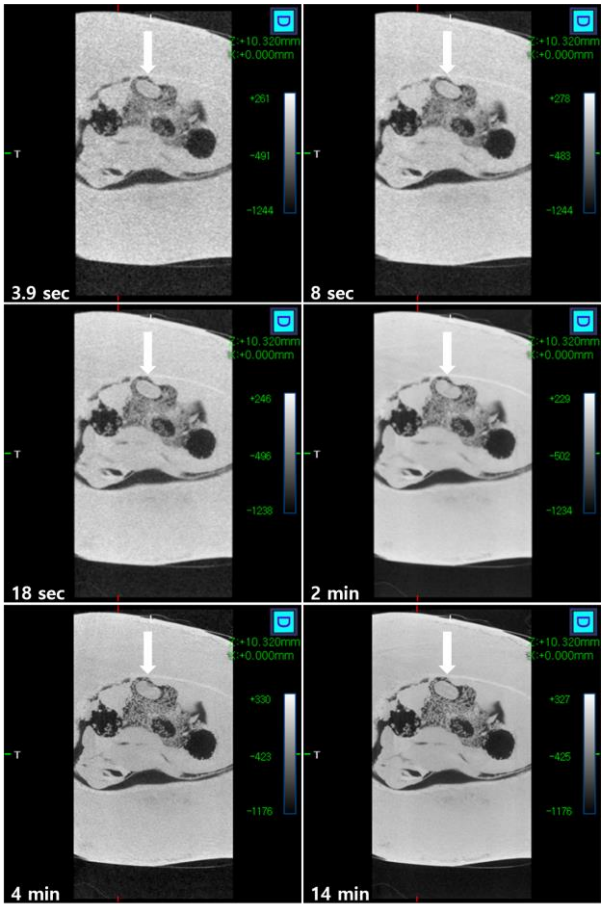

Fig. 1. Mangifera indica CT image with various range of scan time. The white arrow indicates a chestnut weevil.

In the quarantine process, it is important to block pest-infested agricultural products from normal agricultural products. In other words, it is more important to be able to identify pest infestation through CT image rather than CT image quality. The shorter the inspection time, the more suitable for quarantine. To accurately evaluate the effect of scan time, quantitative evaluation of CT images such as CT number and contrast-to-noise ratio (CNR) should be performed.

4. Conclusions

In this study, we investigated optimal scan time of CT images to quarantine pest-infected Mangifera indica. CT images with only few-second scan time were able to identify the artificially inserted chestnut weevil. It is suitable and fast enough to be applied in the quarantine field. In the future, we will verify the validity of few-second CT images through additional quantitative analysis.

Acknowledgements

This research was supported by a fund (PQ20201B010) by the Research of Animal and Plant Quarantine Agency, South Korea. NDT inspection (X-ray CT) was supported by the Soonchunhyang Institute of Medi-Bio Science (SIMS)

REFERENCES

[1] H. Gao, F. Zhu, and J. Cai, A, A review of non-destructive detection for fruit quality, IFIP Adv. Inf. Commun. Technol, Vol. 317, p.133-140, 2010.
[2] B.M. Nicolaï, K. Beullens, E. Bobelyn, A. Peirs, W. Saeys, K.I. Theron, and J. Lammertyn, Nondestructive measurement of fruit and vegetable quality by means of NIR spectroscopy: A review, Postharvest Biol. Technol, Vol. 46, p.99-118, 2007.
[3] A. Suresh, and S. Neethirajan, Real-time 3D visualization and quantitative analysis of internal structure of wheat kernels, J. Cereal Sci, Vol. 63, p.81-87, 2015.