APPLICATION OF QUANTITATIVE X-RAY MICRO-TOMOGRAPHY TO THE IDENTIFICATION OF CHINESE MEDICINAL MATERIALS

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Summary: Quantitative X-ray micro-CT is a practical tool for the microscopic investigation of Chinese medicinal materials (CMMs). Experimental results demonstrated that the quality of CMMs can be evaluated directly via the quantitative information of their characteristic microstructures.

1. INTRODUCTION

Chinese medicine is the valuable wealth that has been accumulated for thousands of years in the treatment of the diseases by Chinese people. There are many Chinese medicinal materials (CMMs) and most of them are from plants. Today, CMMs are increasingly used worldwide, and therefore, the identification and application of CMMs has attracted more and more attentions from scientists. Compared to the traditional identification methods, quantitative X-ray micro-CT is a promising method for its free sample pretreatment, nondestructive, 3D and in situ features, especially for the identification of precious specimens and samples with volatile oils [1, 2].

2. EXPERIMENTAL METHOD

The quantitative X-ray phase-contrast microtomography based on synchrotron radiation was used to investigate the rare, typical and well-known CMM—ginseng. Four different ginseng samples were collected and investigated; these were classified according to their species, production area, and sample growth pattern.

The experiments were performed at the X-ray imaging and biomedical application beamline (BL13W1) of the Shanghai Synchrotron Radiation Facility (SSRF), in Shanghai, China. The third-generation synchrotron radiation facility provides an excellent X-ray imaging resource with the advantages of monochromaticity, high spatial coherence, and high flux density. The Energy range of the synchrotron radiation in this beamline is 8–72.5 keV, which corresponds to the gaps from 17 mm to 35 mm. The maximal beam size is 45 mm (H) × 5 mm (V). The end-station has five different types of X-ray detectors, with different spatial resolutions to meet different requirements of different samples for X-ray imaging, and the pixel size ranges from 0.17 μm to 24 μm. The specific experimental parameters used in the current ginseng research were as follows: the photon energy was set at 14 keV, and the sample-to-detector distance was 10 cm. An Optique Peter X-ray detector was employed, and its effective resolution was 3.7 mm/pixel.

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3. RESULTS

The quantitative characteristic microstructures of ginseng were extracted successfully. The shape, size and position distributions of the calcium oxalate cluster crystals (COCCs), important secondary metabolites that accumulate in ginseng, are revealed by the three-dimensional quantitative imaging method. The volume and amount of the COCCs in different species of the ginseng are obtained by a quantitative analysis of the three-dimensional microstructures, which shows obvious difference among the four species of ginseng investigated. As shown in Figure 1[3, 4]. Experimental results demonstrated that X-ray microtomography is a practical tool for the nondestructive investigation of CMMs.

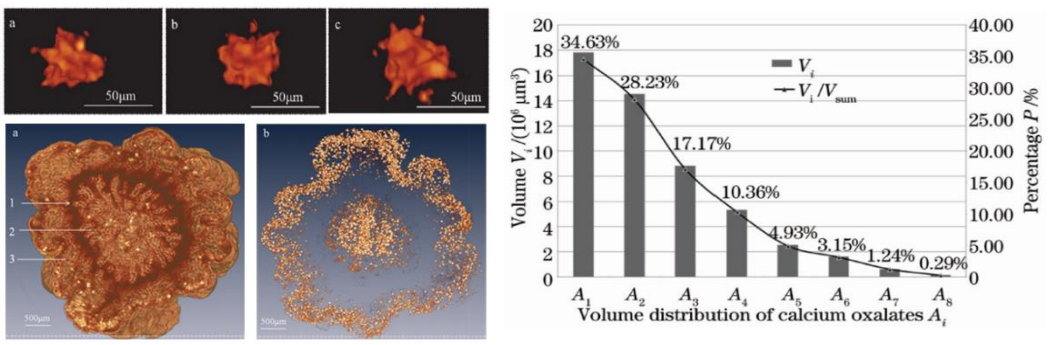
References

[1] X. Wei, T.Q. Xiao*, *et al*. Application of x-ray phase contrast imaging to microscopic identification of Chinese medicines, *Phys. Med. Biol.*, 50, 4277-4286, 2005.

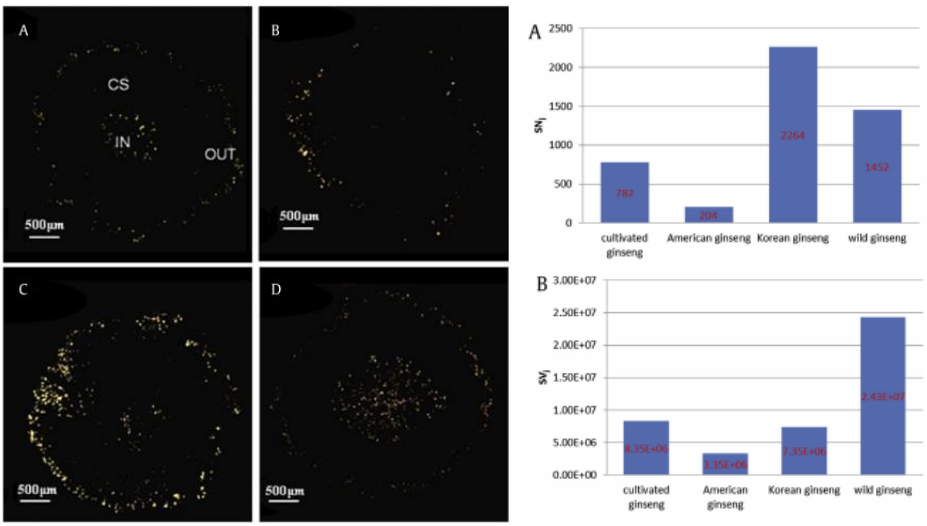
[2] H.L. Xie, B. Deng, *et al*. Latest advances of X-ray imaging and biomedical applications beamline at SSRF, *Nuclear Science and techniques*, 26, 020102, 2015.

[3] L.L. Ye, Y.L. Xue, *et al*. Identification of ginseng root using quantitative X-ray microtomography, *J Ginseng Res*, 41, 290-297, 2017.

[4] Y.L. Xue, Z.T. Liang, *et al*. Microscopic identification of Chinese medicinal materials based on X-ray phase contrast imaging: from qualitative to quantitative, *JINST*, 11, C07001, 2016.



(1) Left: 3D shape (the same crystal at different angles) & distribution of COCCs in wild ginseng; Right: Volume distribution of COCCs of the wild ginseng main root, where Vi is the distribution volume of COCCs with different size of Ai and Vsum is the total volume of all COCCs.



(2) Left: Distribution of COCCs in (A) cultivated ginseng, (B) American ginseng, (C) Korean ginseng, and (D) wild ginseng. Right: Quantitative analysis of COCCs in four kinds of ginseng of 370 mm thickness. (A) total number and (B) total volume.

Figure 1. The extraction and quantitative analysis of COCCs in different ginsengs