Author's Accepted Manuscript

Mechanical Response of Common Millet (Panicum miliaceum) Seeds under Quasi-static Compression: Experiments and Modeling

Benjamin P.J. Hasseldine, Chao Gao, Joseph M. Collins, Hyun-Do Jung, Tae-Sik Jang, Juha Song, Yaning Li

www.elsevier.com/locate/jmbbm

PII: S1751-6161(17)30015-2
DOI: http://dx.doi.org/10.1016/j.jmbbm.2017.01.008
Reference: JMBBM2179

To appear in: *Journal of the Mechanical Behavior of Biomedical Materials*

Received date: 20 August 2016
Revised date: 4 January 2017
Accepted date: 5 January 2017

Cite this article as: Benjamin P.J. Hasseldine, Chao Gao, Joseph M. Collins Hyun-Do Jung, Tae-Sik Jang, Juha Song and Yaning Li, Mechanical Response of Common Millet (Panicum miliaceum) Seeds under Quasi-static Compression Experiments and Modeling, *Journal of the Mechanical Behavior of Biomedica Materials,* http://dx.doi.org/10.1016/j.jmbbm.2017.01.008

Mechanical Response of Common Millet (*Panicum miliaceum*) Seeds under Quasi-static Compression: Experiments and Modeling

Benjamin P.J. Hasseldine[a] Chao Gao[a], Joseph M. Collins[a], Hyun-Do Jung[b], Tae-Sik Jang[c], Juha Song[d]*, Yaning Li[a,]*

[a]Department of Mechanical Engineering, University of New Hampshire, Durham, NH, USA.

[b]Liquid Processing & Casting Technology R&D Group, Korea Institute of Industrial Technology, Incheon, Korea.

[c]Department of Materials Science and Engineering, Seoul National University, Seoul, Korea.

[d]School of Chemical and Biomedical Engineering, Nanyang Technological University, Singapore.

*Corresponding Authors. Email address: yaning.li@unh.edu (Yaning Li).

Abstract

The common millet (*Panicum miliaceum*) seedcoat has a fascinating complex microstructure, with jigsaw puzzle-like epidermis cells articulated via wavy intercellular sutures to form a compact layer to protect the kernel inside. However, little research has been conducted on linking the microstructure details with the overall mechanical response of this interesting biological composite. To this end, an integrated experimental-numerical-analytical investigation was conducted to both characterize the microstructure and ascertain the microscale mechanical properties and to test the overall response of kernels and full seeds under macroscale quasi-static compression. Scanning electron microscopy (SEM) was utilized to examine the microstructure of the outer seedcoat and nanoindentation was performed to obtain the material properties of the seedcoat hard phase material. A multiscale computational strategy was applied to link the microstructure to the macroscale response of the seed. First, the effective anisotropic mechanical properties of the seedcoat were obtained from finite element (FE) simulations of a microscale representative volume element (RVE), which were further verified from sophisticated analytical models. Then, macroscale FE models of the individual kernel and full seed were developed. Good agreement between the compression experiments and FE simulations were obtained for both the kernel and the full seed. The results revealed the anisotropic property and the protective function of the seedcoat, and showed that the sutures of the seedcoat play an important role in transmitting and distributing loads in responding to external compression.

Keywords: Common Millet, Seed, Suture, Anisotropy, Compression, Finite Element