Spatial frequency domain imaging for determining absorption and scattering properties of bruised pears based on profile corrected diffused reflectance

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Abstract

Curved surface of fruit has a great influence on the measurement of absorption (μ_a) and reduced scattering coefficients (μ'_s) by using the spatial frequency domain imaging (SFDI) technique. In this study, a developed SFDI system was used to conduct phase-measuring profilometry (PMP) to obtain the surface height of tested object. Monte Carlo (MC) simulation was conducted on planar and spherical geometric models, and the correction formula for diffuse reflectance (R_d) was then determined by simulation results and validated by tilt standard reflector. The R_d correction effect on estimating μ_a and μ'_s was revealed by five semi-spherical phantoms, which turned out that both the accuracy and uniformity were substantially improved, with the relative error range of 0.78%-11.84% and 2.83%-8.95%, and standard deviation range of 1.89×10^{-5} mm^{-1}-1.42×10^{-3} mm^{-1} and 1.76×10^{-4} mm^{-1} -8.17×10^{-3} mm^{-1} for corrected μ_a and μ'_s respectively. Finally, the proposed R_d correction method was applied to the bruise detection in pears, the comparisons of μ_a and μ'_s maps between normal and bruised pears were conducted. The results revealed that the area around the highest point of normal pear contour was easily to be identified as bruised area before R_d correction; the μ_a and μ'_s maps for normal pear were more uniform, and for bruised pears after the correction, and the injured area was highlighted for bruised pears. The profile correction method proposed in this study, coupled with the SFDI technique, was essential for precise measurement of μ_a and μ'_s of pear tissues, resulting in less misclassification for bruise detection of pears.