MECHANICAL IMPEDANCE OF FOOD MATERIALS

József Felföldi, István Kertész, Dávid Nagy, Viktória Zsom-Muha

Hungarian University of Agriculture and Life Sciences, Institute of Food Science and Technology, Department of Measurements and Process Control

felfoldi.jozsef@uni-mate.hu

ABSTRACT

The mechanical properties of food materials are very important quality characteristics for the whole food chain from the harvesting and postharvest treatment to processing or consumption. Among other measurement methods, the dynamic methods (acoustic response, impact and/or wave-propagation measurements) offer advantageous possibilities due to their speed and non-destructive nature. However, the applicability and the information provided by these methods are limited. Complex description of all components of a mechanical system (mass, stiffness, damping) can be given by the mechanical impedance approach: Z = F/v, where 'F' is the force, applied to the system and 'v' is the velocity of the measurement probe. These properties have spectral behavior. Similarly to the analysis of an electronic circuit or a continuous control system, the behavior can be described by differential equations and the solution is given by the transfer-function, applying Fourier-transformation. This way, applying sine-wave forces or displacements on the system, it can be investigated in frequency-domain (instead of time-domain).

To test the approach experimentally, model-materials (gelatin half-spheres of increasing hardness due to increasing concentration) were used. In our experiments a shaker (K2004E01 Smartshaker, The Modal Shop, USA) was used to generate the sinusoidal excitation of the sample and a PCB Piezotronics 288D01 Impedance-Head measured the input and output signal of the mechanical system. A RULA RL-C21 instrument was applied to control the shaker and for conditioning and processing of the sensor signals. The frequency-dependent signals of the impedance head are the a(f) acceleration and F(f) force parameters. Due to the sine-wave excitation, derived parameters, as the v(f) velocity and x(f) displacement can be simply calculated from the measured acceleration signal. In order to get almost directly the mechanical impedance spectra, linearly increasing acceleration was generated by the controlling instrument in the desired frequency range, resulting in constant velocity. This way, the F(f) spectra have the same shape, as the desired Z(f) impedance spectra, but M(f) = 1/ Z(f) mobility and the FRF(f) = x(f)/F(f) frequency-response function can be determined as well for comparison with literature data.

For the model-materials, the theoretical impedance-functions were fitted to the measured spectra in Excel by Solver. The fitted parameters were compared to the characteristics, determined by traditional methods (SMS penetrometer). The good fitting results and the agreement between the parameters are convincing about the applicability of the approach. Further investigations were started about the methodological properties, the optimal setup and the applicability of the method on more complex samples (real foods).