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# **An Innovative Approach for De-Crystallization of Honey by Radio Frequency Heating: Computational Monitoring of Process Efficiency**

**UYAR R. (2), KARATAS O. (1), BERK B. (3), OZTOP M. (3), ERDOGDU F. (1)**

1 Ankara University, Ankara, Turkey

2 Aksaray University, Aksaray, Turkey

3 Middle East Technical University, Ankara, Turkey

Industrial de-crystallization of honey is carried out using conventional methods of hot water (12-18 h at 60 °C) or air (24-36 h at 60 °C) with the cost of energy and process time. Radio frequency (RF) process, with its longer penetration depth and volumetric heating feature, is an innovative approach to increase process efficiency. It might be used for honey de-crystallization. However, monitoring the de-crystallization process is important for sustainability and efficiency since even the presence of smaller crystals might lead to further re-crystallization during storage. Therefore, the objectives of this study were to introduce RF de-crystallization and monitor this process with time-domain TD-NMR for crystal size and content of honey samples.

For this purpose, pine honey samples were used in a staggered through electrode configuration (10 kW - 27.12 MHz) RF system. Temperature change of honey samples was recorded during the process at 15 cm electrode gap and 5000 V potential. This data was used for validating the computational model (developed for honey de- crystallization using Comsol Multiphysics V5.6). TD-NMR experiments were, on the other hand, performed to monitor the de-crystallization at 40 to 70 °C with a magnet operating at 20.34 MHz. Relative crystal contents (for fine and coarse crystals) were recorded using a solid echo pulse sequence.

Experimental TD-NMR data was used to determine D- and z-values of the de-crystallization process, and these kinetic parameters were coupled with temperature change during RF processing. The results demonstrated the NMR monitoring for RF processing while the experimentally validated computational model well determined the required process time. TD-NMR data enabled further determination of crystal amount through the process. Use of RF processing led more than 50% reduction in de-crystallization time for 20 kg samples in an industrial scale process compared to conventional approaches.

RF heating for honey de-crystallization was demonstrated as an efficient and possible sustainable industrial processing.