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ULTRASONIC PROCESSING AND MECHANICAL TESTING IN FOOD TECHNOLOGY AND BIOTECHNOLOGY

Damir Semenski[1(*)], Mladen Brnčić[2], Tomislav Bosiljkov[3], Sven Karlović[4], Damir Ježek[5], Branko Tripalo[6]

[1]Faculty of Mechanical Engineering and Naval Architecture, University of Zagreb, Ivana Lučića 5, HR-10000 Zagreb, Croatia

[2,3,4,5,6]Faculty of Food Technology and Biotechnology, University of Zagreb, Pierottijeva 6, Zagreb, Croatia

[(*)]*Email:* damir.semenski@fsb.hr

ABSTRACT

The paper presents the methodologies and examples of the application of ultrasound on milk homogenization and the influence on its physical properties, the application of ultrasound in the operation of drying apple slices and using the power ultrasound sieving of corn flower and mechanical testing of food extrudates.

INTRODUCTION

Quality management of food products is of great importance in maintaining the existing product on the market i.e. improve its quality or developing novelties. Throughout this process of characterization of physical/mechanical properties a particular product has an important role, whether on their verification or impact on their production based on the results of treatment and testing.

HIGH INTENSITY ULTRASOUND IN FOOD TECHNOLOGY

Implementation of high intensity ultrasound in food technology and biotechnology (intensities above 1 W/cm^2, usually in range 10 – 1000 W/cm^2 and frequencies 20 – 100 kHz) become one of the most progressive technologies that are used in many technological processes in food industry. The most represented are drying, mixing, homogenization, extraction, crystallization etc. Stability and physical/chemical properties of food emulsion usually depend on the method to create it. The application of ultrasonic homogenization influenced by high intensities of ultrasonic waves is defined by diameter of the ultrasonic probe and nominal power of ultrasonic processor.

Fig.1 shows the microscopic pictures of fat globules cow milk, which was homogenized with ultrasonic processor “UP 100 H” produced by “Dr Hielscher” company (Teltow, Germany). Parameters of homogenization were: constant frequency of 30 kHz, cylindrical probes with diameters S7 (d_{S7} = 7 mm) and S10 (d_{S10} = 10 mm), ultrasonic treatments performed by amplitude (A = 20, 100 %) and time of treatment t = 10 min.

Experimental results represent the influence of different ultrasonic process parameters with different types of ultrasonic probes on degree of homogenization of cow milk expressed over variance and changes on observed physical properties.

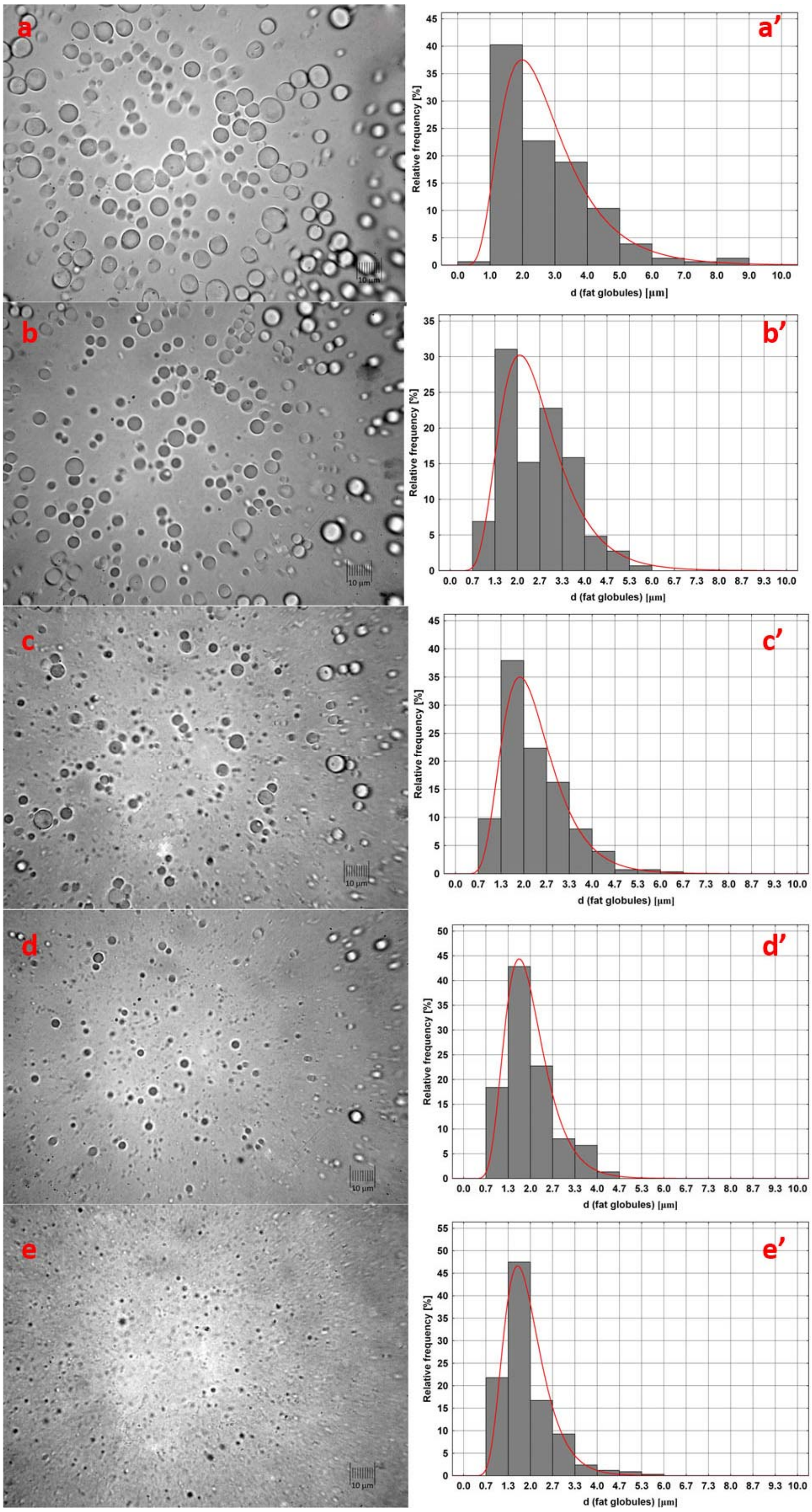

Fig.1 Fat globules (a– inhomogeneous; b – A=20%, S7; c – A=20%, S10; d – A=100%, S7; e – A=100%, S10)

Designing of drying operations needs accurate models of drying which are simple and fast for use, so optimal parameters can be calculated instead of based on series experiments. Drying process, which includes ultrasonic treatment is suitable to change physical and chemical properties of fruit, and as such should be carefully modeled to minimize loss of food quality and process costs. Any modification to the drying parameters in standard setup of system settings in laboratory and industry practice leads to inability of the previously established empirical model to fit new experimental data. Artificial neural networks (ANN) can overcome this limit by inserting data from the all input variables; so neural networks show excellent fitting to experimental data, independently of used input parameters obtained in experiments.

Multi-layer perception was selected as a relevant network type for training with experimental data. Selected input variables were amplitude of ultrasound, thickness of slices and drying temperature, with water content as output variable, as presented in Fig.2.

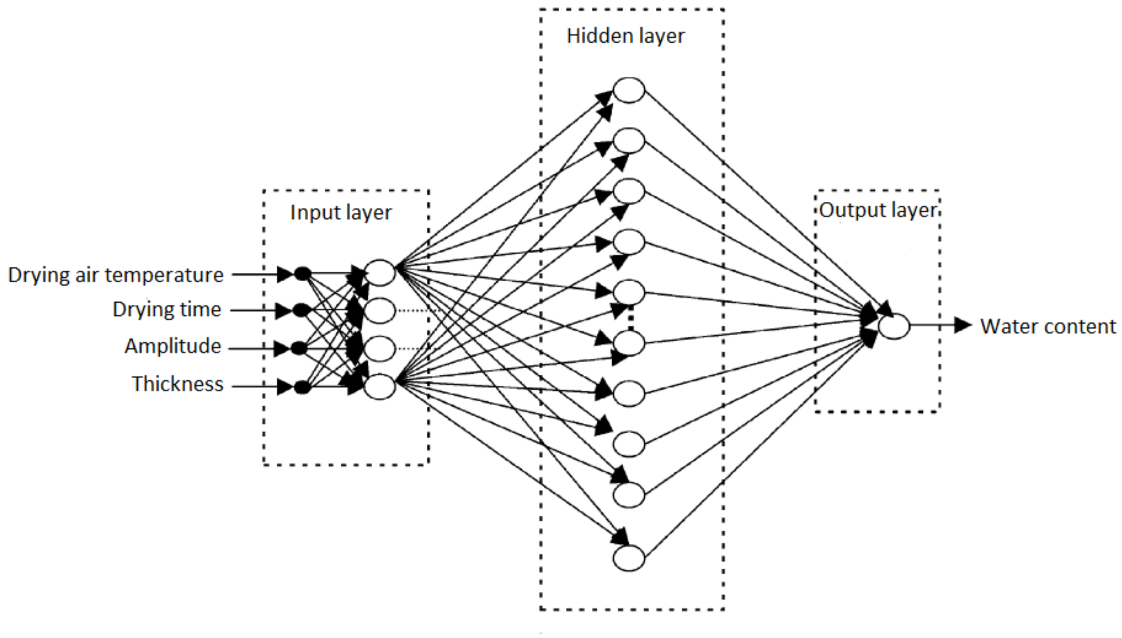

Fig.2 Model of artificial neural network based on 4 inputs

Based on experimentally gathered data, the example shown in Fig.3 can give the amplitude of ultrasound vs. influence on drying time and water content, independently of drying temperature and apple slice thickness. Using the ANN, application of ultrasound in drying operations can be successfully modeled, as this kind of heuristic network is not strictly limited to specific experiment and allows for broad range of values for larger number of input parameters.

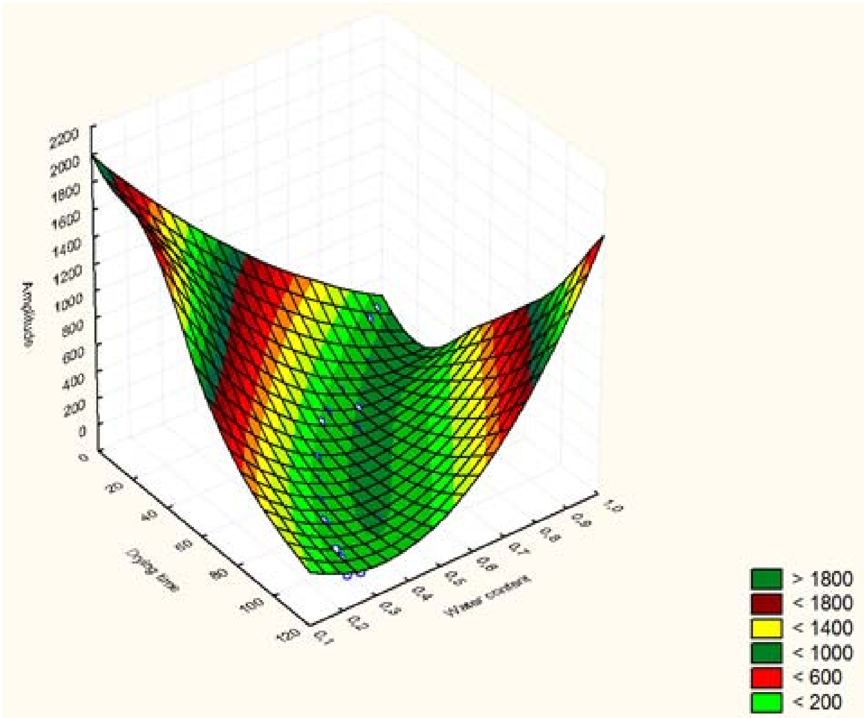

Fig.3 Amplitude of ultrasound vs. water content vs. drying time vs. based on ANN

During extrusion processing of corn flour and whey or soy proteins blends are interject, then it is very important to know precise particle size of the interjected blends. Determination of particle size and separation of desirable fraction of corn flour was improved by variations in power ultrasound process of sieving, e.g. different time of sieving and amplitude of ultrasound in separation of desirable fraction.

Samples sieved for 15 minutes without ultrasound caused blocking of sieves from the top of the device (Fig.4), but most of blocking occurs on sieve of 450 μm.

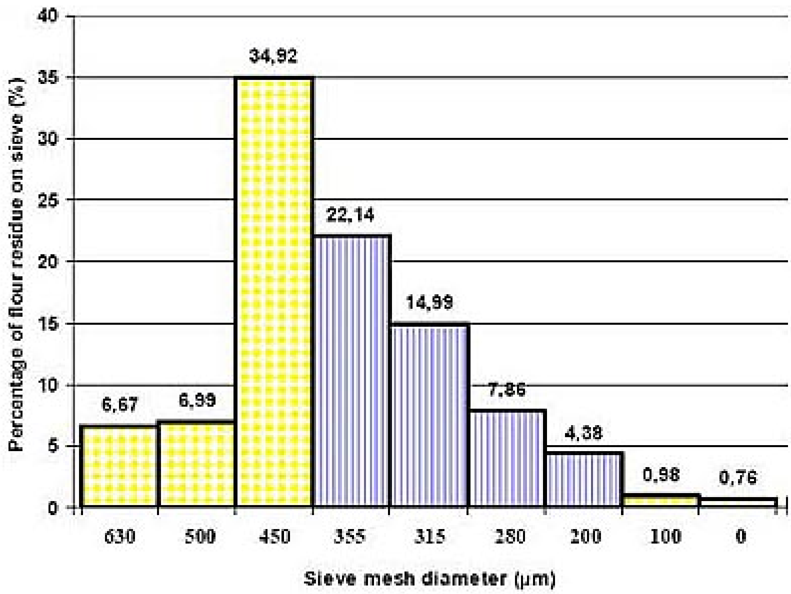

Fig.4 Sieving without ultrasound

Using power ultrasound process of sieving was improved. The influence of ultrasound amplitude, during the same time of sieving, managed to break down the most of the developed agglomerates created within first minute of the shaking (Fig.5).

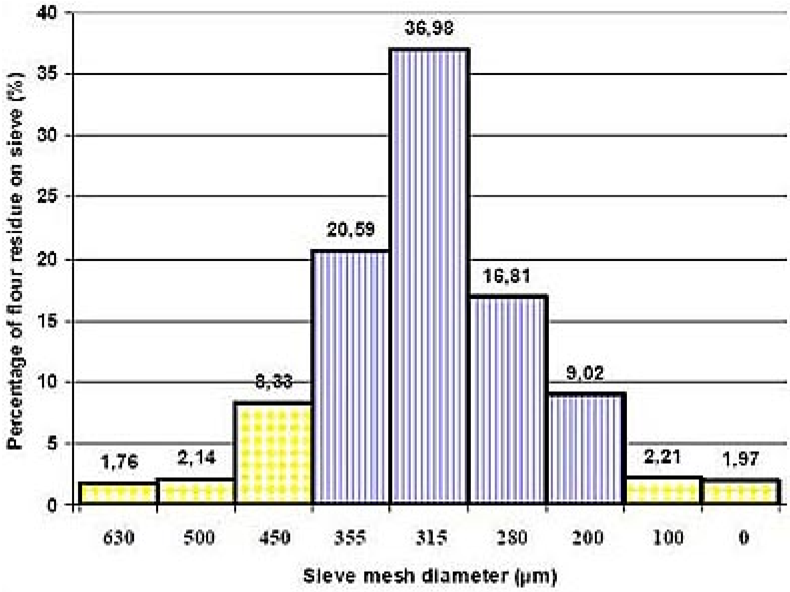

Fig.5 Sieving with ultrasound

MECHANICAL TESTING OF CONSUMABLE FLIPS

Physical properties of the biopolymers primarily determine the texture of the product, usually by detecting the resistance of the food to the applied force. Most foods have heterogeneous structure, what makes difficult the determination of material mechanical properties. Consumable flips material has porous, non-homogenous structure that makes production of standard shaped specimens for material testing virtually impossible. We introduce an experimental method that includes the displacement registration during the conventional time-controlled compression tests. The results of these experiments were influencing to flips structure and material porosity directly affected to the product nutritional qualities.

The actual deformation distribution analysis was carried out by the object grating method at the specimen surface cut. The area based image-matching algorithm is applied to the image analysis of the reference unloaded and loaded stages, as shown as the series of prints in Fig.6.

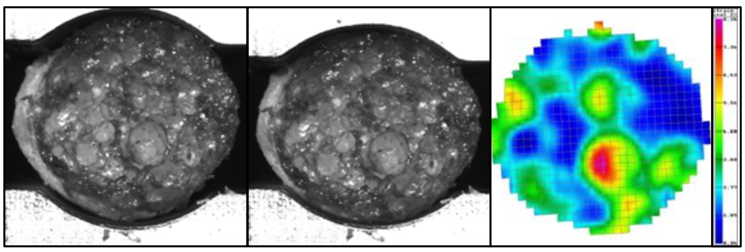

Fig.6 Unloaded and deformed stage of the flips surface cut

The automatically captured force and grip displacements were analyzed. Typical stress/strain response diagram obtained from these data is shown in Fig.7.

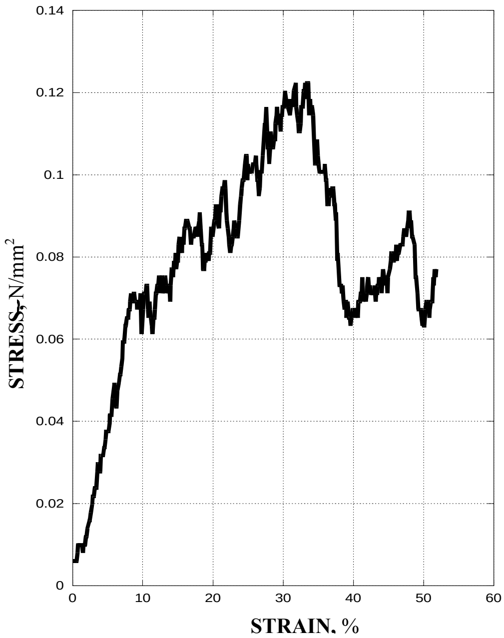

Fig.7 Stress-strain diagram of tested consumable flips

RESULTS AND CONCLUSIONS

Mechanical properties of food products are closely connected with the quality of the product. The novelties in food treatment during processing and production set the innovative procedures of ultrasound application and stress-deformation analysis. The performed experiments show significant influence on all observed mechanical properties, while the statistical analysis of the experimentally recorded data leads exactly to the best-consumed samples thus directly confirming the methods.

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