Production of nutrient bars by ultrasonic compression: Optimal processing window predictability

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Conventional nutrition bars are made by mechanical compression of cereal flours. Typically, a force of 9,000 N is applied. Agglomeration of particles under mechanical compression requires the use of binders like sugar syrup. Bar texture is negatively impacted by moisture during storage. Ultrasonic compression (UC) is a novel approach to produce nutrient-dense bars with reduced moisture thereby increasing the shelf life. Temperature increase during ultrasonic welding process due to conversion of mechanical energy to heat aids agglomeration of particles.

The objective of the study is to evaluate the effect of various cereal flours on ultrasonic compression parameters to produce nutrition bars with structural integrity and desired mechanical properties.

Wheat, corn, oat, and buckwheat flours were used. UC bars were fabricated using ultrasonic welding equipment working at 20 kHz. Flour with 22 % moisture was placed in a mold and the horn was lowered with a 0.015 m/sec velocity until a trigger force of 222N was reached after contact with flour. Weld energy and percent amplitude were selected as processing parameters and welding time was recorded to establish a process window for production of bars with structural integrity. Mechanical properties tests were carried out using a texture analyzer and fracture stress was calculated. Temperature increases for the process were determined with an infrared camera. The relationships among fracture stress and UC processing parameters and flour properties were developed.

A “successful” bar production parameters region was established within the envelope of weld, energy, percent amplitude, and weld time. The region remained within 2200-3750 J, 60-100% amplitude, and 2-3 seconds of weld time. Processing window showed differences among flours due to differences in their composition and particle sizes. A temperature contour plot indicated a temperature range of 50-65 C for bar production. Fracture stress of the bars varied among flours, with the highest, 3341 kPa, for whole wheat flour and the lowest, 242kPa, for oat flour.Development of a predictive capability for fracture stress of bars will lead to optimization of UC parameters for various flour systems to better serve both processor and consumer needs.