Tailored ohmic heating concepts for the targeted processing of vegetables

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Ohmic heating (OH) is an innovative heating technology which enables the optimization of conventional thermal processes with regard to resource efficiency, process efficacy and quality retention of the product. Through volumetric heating, OH provides the potential to reduce processing times and energy consumption which contributes to sustainable energy management in times of the current energy crisis. However, product and process parameters influence the efficiency and homogeneity of OH processes. Therefore, this study aimed to optimize OH treatments to create targeted thermal processes for inhomogeneous raw materials such as vegetables. For this purpose, thermal and electrical pre-treatments were used to disintegrate the vegetable cells to minimize non-uniformities in the electrical conductivity of the tissue which influence the heating homogeneity. The changes in local conductivity were assessed before and after different pre-treatments and during OH. Additionally, the influence of different pulse repetition frequencies (12 kHz and 300 kHz) was assessed to accelerate the heating rate and uniformity. The effects were analyzed by thermal imaging and temperature kinetics using product-specific cooking values. The effects on the cooking behavior were evaluated by cell disintegration index, cooking loss, dry matter, color and texture in different product parts. OH processes were compared with conventional boiling in water. The results of the study showed distinct potential for the use of pre-treatments for a rapid and more homogeneous OH of vegetables (cooking time reduction of up to 36 %) and accelerated heating rates due to cell disintegration of up to 90 % of the plant tissue. The use of a higher pulse repetition frequency (300 kHz) led to increased electrical conductivities (up to 2 mS/ cm higher) in the vegetable tissue which resulted in improved heating uniformity compared to 12 kHz. The use of tailored process conditions with additional pre-treatment showed enhanced product properties like increased color retention (up to 90 %) and texture uniformity of the cooked vegetables. The results provide a better understanding of the influence of pre-treatments and specific process parameters on product properties during and after OH which enables process optimization and the implementation of targeted processing concepts for OH with lower energy requirements.