
Microwave hydrothermal treatment of chickpea seeds: mass transfer dynamics

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In the context of legume consumption, the preparation of these dry whole seeds, such as chickpeas, relies on key hydration and cooking operations. These operations require a more or less long time depending on the conditions: soaking at room temperature followed by cooking, soaking and cooking simultaneously, with or without pressure. During the soaking of seeds, water absorption is the main mechanism inducing swelling and changes in physical characteristics, beyond a temperature of 55°C, water absorption is accompanied by changes in starch granules, via the initiation of gelatinization mechanisms and can lead to a significant loss of soluble solids. Microwave treatments can accelerate the mass and heat transfer process. The present work aims to study the mass transfer kinetics during the microwave hydration-cooking step of chickpea seeds in excess of water under different conditions (400, 800 and 1200 W), in comparison with the conventional cooking on electric plate. Chickpea seeds are assimilated to a sphere (sphericity = 0.87; equivalent diameter = 9.5 mm; specific convective heat exchange surface = 310 mm²). The results show that the water uptake kinetics are different depending on the type and conditions of the treatment applied. The water content of the seeds increases monotonically for the conventional and microwave (400W) treatments. For microwave treatments at high powers (800 and 1200W), the water content increases rapidly, then stabilizes around a maximum value and then decreases slightly. Losses of soluble solids increase during the cooking process. An increase in microwave power leads to higher losses. Changes in physical characterizations of the seeds are in agreement with the mass transfer results. A temperature gradient hypothesis is assumed to describe the unexpected pattern of water uptake kinetics for high microwave power treatments, associated with volumetric heating by electromagnetic waves. During the treatment, the core temperature of the seeds could exceed 100°C and induce changes in the seed core structure, while the seed surface remains at stable around 100°C, in contact with boiling water. These modifications could modify the mechanisms of water transfer from the surface to the core classically. These hypotheses must be confronted with modelling and numerical simulations.