Computer simulation to improve radio frequency heating uniformity of seeds by inserting horizontal aluminum and polypropylene (PP) plates in a rectangular PP container

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Uneven temperature distribution is a major barrier for applying radio frequency (RF) heating to replace traditional thermal treatments in foods or agricultural products processing, such as pasteurization of edible seeds. In this study, simulation models of watermelon seeds heated by RF energy were established using the commercial COMSOL software with or without inserting polypropylene (PP) or aluminum (AL) plate into a rectangular PP container and validated based on experimental results. The effect of inserting PP or AL plate at different horizontal positions on RF heating behavior of watermelon seeds was also analyzed by the validated simulation model. The results showed that inserting PP or AL plate caused different electric field distribution in the second layer of seeds. Meanwhile, when the insertion height increased from 5 to 35 mm, the volumetric RF heating uniformity index (0.033-0.118) for the second layer in seeds with inserting the AL plate was lower than that (0.127-0.165) of samples with inserting a PP plate. The optimal heating uniformity index could be obtained by inserting multiple AL plates with intervals of 10 mm among watermelon seeds. These findings can further be expanded to optimize the heating uniformity for developing an effective RF pasteurization and disinfestation protocol in foods or agricultural products without reducing their quality.