Title Including product and package variability in model based design of modified atmosphere packages using Monte Carlo simulation

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Abstract

Butterhead lettuce is not often marketed as fresh-cut because of its mechanical fragility and sensitivity to develop browning, especially on the cut surfaces. Literature shows that superatmospheric oxygen MAP could resolve the browning problem of fresh-cut butterhead lettuce. In a first step a deterministic respiration model for fresh-cut butterhead lettuce was developed to describe oxygen consumption and carbon dioxide production under oxygen conditions between 0 and 100%, carbon dioxide conditions up to 20% and for temperatures between 1 and 10°C. Models to predict the development of lettuce browning, the growth of Pseudomonas fluorescens and Listeria innocua at the same range of oxygen and carbon dioxide conditions were developed as well. In a second step all these submodels were combined with a foil diffusion model into a global deterministic model to predict oxygen and carbon dioxide changes in a modified atmosphere package of fresh-cut lettuce at superatmospheric oxygen condi¬tions. This deterministic MAP-model was able to describe the development of brown¬ing and to predict the microbial spoilage and safety of the packaged fresh-cut lettuce. A sensitivity analysis revealed those model parameters having the most important effects on the predicted package response in quality and safety. In a third step this information was used to expand the deterministic model into a stochastic one taking into account the variability of the important model parameters which was measured. The stochastic model was used to design a good performing package. The designing process involved deciding on the amount of product to be packed in the best available foil and to determine the package dimensions by simulation. The best simulated design was then actually implemented. Oxygen and carbon dioxide concen¬tration, and browning were measured at several points in time to validate the model and a reasonable agreement between predicted and measured values was obtained.