Title Modelling the effect of gas composition on the gas exchange rate in Perforation-Mediated Modified Atmosphere Packaging

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Abstract

Modified Atmosphere Packaging (MAP) relies on modification of the atmosphere inside a package, achieved by the natural interplay between the respiration of the product and the transfer of gases through the package. Polymeric films are the most usual packaging material but because of the increase in the consumption of fresh-cut products with a higher respiration rate and higher tolerance to CO_2, alternative materials are being investigated. The perforation-mediated package is one of those alternatives, where the regulation of the gas exchange is achieved by single or multiple tubes that perforate an otherwise impermeable packaging material. From an engineering point of view, the transport of gases through perforations is a complex phenomenon that involves diffusion gradients together with co-current transport of multiple species, with oxygen entering the package and carbon dioxide leaving it. The influence of one species transport in the other has not been studied so far. The objective of this work was to analyse the effect of initial concentration of CO_2 on the effective mass transfer coefficients of O_2 (K_{O2}) and CO_2 (K_{CO2}) in perforation-mediated MAP. K_{O2} ranged from (6.99 ± 0.05) × 10^{-8} (m^3 s^{-1}) to (28.50 ± 0.01) × 10^{-8} (m^3 s^{-1}) and for K_{CO2} from (6.45 ± 0.04) × 10^{-8} (m^3 s^{-1}) to (28.32 ± 0.01) × 10^{-8} (m^3 s^{-1}). On average K_{O2} decreased by approximately 15% with an increase of CO_2 initial concentration from 25% to 100%. K_{CO2} was insensitive to the composition of the gas mix. The permeability ratio (β) varied from 0.73 ± 0.01 to 1.34 ± 0.01. A mathematical model considering the co-current effect of CO_2 flux on the gas exchange rate for O_2 was developed. These results suggest that there is a significant drag effect in the gas exchange process that should be taken into consideration when designing perforation-mediated MAP.