Abstract

Perforation-mediated Modified Atmosphere Packaging (MAP) relies on the use of tubes that perforate and otherwise airtight package to control the gas exchange rate. Permeability (K) values for O_2 and CO_2 depend on tube dimensions, tube location, package geometry and volume. Temperature has been reported not to have a significant effect when the packages are protected from ventilation, but this is not the case in real storage and the increased air turbulence as temperature decreases is likely to increase the gas exchange rate. Several models have been published in the literature to predict the permeability coefficients in a perforation-mediated system as a function of tube diameter (D) and length (L). These models have been developed using tube with diameters and lengths in the range of 7 to 17 mm and 7 to 31 mm, respectively, and we found that they over-predict the gas transfer rate when applied to smaller tubes. The aims of this work were to study the effect of external turbulence on the gas exchange rate through small perforations, and to develop a mathematical model to predict the effect of tube dimensions and air velocity on gas permeability. Small PVC tubes with different dimensions (all the combinations of diameters 1.5, 3.0 and 4.5 and lengths fo 2.0, 4.0 and 6.0 mm) were inserted half inside half outside across tinplate twist-off lids fitted with stoppers for gas sampling. Glass jars (1.9 dm^3) were flushed with 20-23% v/v CO_2 (with balance N_2) and stored in a walk-in controlled temperature room. The temperature of the room was maintained within 1 °C of the set temperature (5, 10 and 15 °C) and the air velocity increased with decreasing temperature. Permeability values for O_2 were in the range $(0.84 \pm 0.01).1.0^{-8}$ to $(8.20 \pm 0.01).1.0^{-8}$ (m^3/s) and for CO_2 they varied from $(0.87 \pm 0.01).1.0^{-8}$ to $(7.000 \pm 0.01).1.0^{-8}$ (m^3/s). The permeability ratio varied between 0.82 and 1.04, depending of the tube dimensions and temperature tested. Results showed that, as expected, air velocity and tube diameter have significantly positive effect on the permeability values, whereas tube length has a negative effect. The data were well describe bed by a model published in literature, $K = aD^bL^c$, but the model constant were different from those reported for larger tubes; furthermore constant a increased with air velocity while constant b decreased. The results suggest that storage at lower temperatures actually increases the permeability coefficients but decreases their sensitivity to tube diameter. The indirect effect of temperature must therefore be taken in consideration when designing perforated-mediated MAP for fresh produce.