Predicting Food Waste and Losses Reduction for Fresh Products in Modified Atmosphere Packaging

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Abstract : To increase the very short shelf life of fresh fruits and vegetable, Modified Atmosphere Packaging (MAP) allows an optimal atmosphere composition to be maintained around the product and thus prevent its decay. This technology relies on the modification of internal packaging atmosphere due to equilibrium between production/consumption of gases by the respiring product and gas permeation through the packaging material. While, to the best of our knowledge, benefit of MAP for fresh fruits and vegetable has been widely demonstrated in the literature, its effect on shelf life increase has never been quantified and formalized in a clear and simple manner leading difficult to anticipate its economic and environmental benefit, notably through the decrease of food losses. Mathematical modelling of mass transfers in the food/packaging system is the basis for a better design and dimensioning of the food packaging system. But up to now, existing models did not permit to estimate food quality nor shelf life gain reached by using MAP. However, shelf life prediction is an indispensable prerequisite for quantifying the effect of MAP on food losses reduction. The objective of this work is to propose an innovative approach to predict shelf life of MAP food product and then to link it to a reduction of food losses and wastes. In this purpose, a 'Virtual MAP modeling tool' was developed by coupling a new predictive deterioration model (based on visual surface prediction of deterioration encompassing colour, texture and spoilage development) with models of the literature for respiration and permeation. A major input of this modelling tool is the maximal percentage of deterioration (MAD) which was assessed from dedicated consumers' studies. Strawberries of the variety Charlotte were selected as the model food for its high perishability, high respiration rate; 50-100 ml CO_2/h/kg produced at 20°C, allowing it to be a good representative of challenging post-harvest storage. A value of 13% was determined as a limit of acceptability for the consumers, permitting to define products' shelf life. The 'Virtual MAP modeling tool' was validated in isothermal conditions (5, 10 and 20°C) and in dynamic temperature conditions mimicking commercial post-harvest storage of strawberries. RMSE values were systematically lower than 3% for respectively, O_2, CO_2 and deterioration profiles as a function of time confirming the goodness of model fitting. For the investigated temperature profile, a shelf life gain of 0.33 days was obtained in MAP compared to the conventional storage situation (no MAP condition). Shelf life gain of more than 1 day could be obtained for optimized post-harvest conditions as numerically investigated. Such shelf life gain permitted to anticipate a significant reduction of food losses at the distribution and consumer steps. This food losses' reduction as a function of shelf life gain has been quantified using a dedicated mathematical equation that has been developed for this purpose.

Keywords : food losses and wastes, modified atmosphere packaging, mathematical modeling, shelf life prediction
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