Bundesministerium
für Ernährung
und Landwirtschaft

FreshPack

Mathematical Modelling of Fresh Produce Packaging, Storage and Supply Chain

Land/Länder	Deutschland und Iran
Fördernde Organisation	Bundesministerium für Ernährung und Landwirtschaft – BMEL
Projektträger	Bundesanstalt für Landwirtschaft und Ernährung – BLE
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Projektbudget	
Projektlaufzeit	3 Jahre (2018-2020 & 2021-2022)
Schlagwörter	Fresh produce, packaging, storage, modelling, shelf-life

Hintergrundinformation	A major part of the annual food loss, about 45 % comes from fresh horticultural produce, most of which are highly perishable. Fresh fruit and vegetables continuously lose their quality after harvest due to their physiological behaviour including respiration and transpiration. Respiration causes senescence, loss of firmness and oxidative mass loss of fresh produce. The main factors affecting the respiration rate are temperature and gas composition in the ambient surrounding the fresh produce. The temperature has a direct relationship with the respiration rate. Low O_2 and high CO_2 concentration in the ambient surrounding the produce can decrease the respiration rate. Fresh produce has also a high amount of moisture in the intracellular space and therefore loses water due to transpiration. The transpiration is driven by a vapour pressure deficit between the product surface and headspace. Water loss is one of the main causes of commercial and physiological deterioration of fresh produce, in the form of wilting, shrivelling, and decreasing stiffness, turgidity and succulence. Exposing the fresh produce to an atmosphere with high humidity can control the moisture loss and preserve the quality. The desired atmosphere may be achieved by active control of gas composition and humidity in the storage atmosphere (controlled atmosphere) or by packaging the fresh produce, so that the desired gas composition and high humidity are achieved passively, by interaction with respiration and transpiration of fresh produce. Proper adjustment of environmental conditions surrounding the fresh produce such as temperature, relative humidity and gas composition play an important role in reducing the metabolic activity and thereby preserving quality and extending the shelf life of fresh produce. Packaging provides an additional barrier, which in a complex interaction with respiration and transpiration, may lead to a different gas composition and humidity than ambient. More complexity arises when environmental conditions such as temperature and humidity fluctuates within the supply chain, i.e. from the harvest to consumption. In addition, natural variation among the individual fruit or vegetables of even the same variety, cultivation, growing and process results in an additional uncertainty.
Projektziel	The core aim of this project was to model this complex interaction for predicting the shelf life, and optimization of the supply chain for shelf life extension. For this, mathematical modelling was used to simulate the physiological behaviour of fresh produce as a function of environmental variables such as temperature, gas composition and relative humidity. Also, the barrier properties of packaging film and the physical behaviour of active packaging materials such as moisture absorbers was integrated to the modelling. In addition, quality changes were modelled and used to predict the shelf life of fresh produce under given supply chain conditions. The mathematical modelling system was also used in the design of modified atmosphere transport containers. Such a container was used to tune the gas exchange as a function of

	temperature changes and kept the desired gas concentration constant despite the temperature fluctuations.
Projektergebnisse	• A comprehensive mathematical model was developed which considered different aspects in packaging, storage and supply chain of fresh produce. It could predict the packaging gas concentration (O_2 and CO_2) and humidity can by investigating the interaction between the physiological behaviour of fresh produce including respiration and transpiration, physical behaviour of packaging materials including gas/water vapour permeation, moisture absorption, and environmental conditions including temperature, humidity, and gas composition. • The second outcome of this research was a model to predict the quality and shelf life of fresh produce through the supply chain conditions based on the respiration and transpiration behaviour of fresh produce. This was done by integrating the models related to the quality parameters of fresh produce in the currently developed modelling approach.
Empfehlungen	• Sensitivity analysis based on the variation range of input variables to the mathematical model to see the effect on the model predictions. • Development of produce-specific shelf life indices, which are predictable as a function of supply chain conditions such as temperature, relative humidity and gas composition.
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