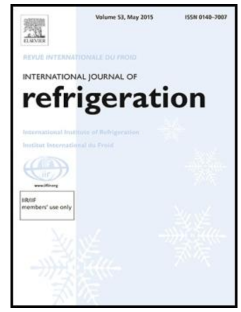
Accepted Manuscript



Title: A numerical evaluation of adaptive on-off cooling strategies for energy savings during long-term storage of apples

Author: W. Gruyters, P. Verboven, M. Delele, S.G. Gwanpua, A. Schenk, B. Nicolaï

PII: S0140-7007(17)30402-4
DOI: https://doi.org/doi:10.1016/j.ijrefrig.2017.10.018
Reference: JIJR 3786

To appear in: *International Journal of Refrigeration*

Please cite this article as: W. Gruyters, P. Verboven, M. Delele, S.G. Gwanpua, A. Schenk, B. Nicolaï, A numerical evaluation of adaptive on-off cooling strategies for energy savings during long-term storage of apples, *International Journal of Refrigeration* (2017), https://doi.org/doi:10.1016/j.ijrefrig.2017.10.018.

A numerical evaluation of adaptive on-off cooling strategies for energy savings during long-term storage of apples

W. Gruyters[a], P. Verboven[a], M. Delele[a], S.G. Gwanpua[a,c], A. Schenk[b], B. Nicolaï[a,b,*]

[a] Postharvest group, BIOSYST-MeBioS, KU Leuven, Leuven, B-3001, Belgium

[b] Flanders Centre of Postharvest Technology, Leuven, B-3001, Belgium

[c] Centre for Postharvest and Refrigeration Research, Massey University, Palmerston North, New Zealand

[*] Corresponding author. Email: bart.nicolai@kuleuven.be

Highlights

- A transient CFD model is developed to analyse temperature dynamics in a coolstore
- Effects of cooling control on quality change and energy consumption are calculated
- Temperature fluctuations are largest near the edges of the fruit stack
- Temperature heterogeneity causes product quality change heterogeneity in the stack
- A larger on-off cooling differential for the same setpoint consumes more energy

Abstract

The main energy costs of long-term apple storage are associated with cooling. Reducing these costs without compromising product quality may be possible with minor room temperature increases. This paper presents a transient CFD model to evaluate automatic on-off cooling control based on different temperature differentials (0.4, 0.5 and 0.7 °C around a setpoint). Effects on temperature uniformity, quality changes and energy consumption during long-term storage of apples were calculated. A model for apple firmness change kinetics was coupled to the CFD model and applied to calculate changes in quality uniformity in a coolstore affected by spatiotemporal fluctuations in temperature. Large temperature fluctuations were observed near the outer edges of the stack and were more pronounced with a higher cooling differential. Using a small cooling differential around the setpoint temperature showed a better overall performance in terms of energy consumption and final product quality.

KEYWORDS: Energy saving; apple storage; computational fluid dynamics; porous medium; FRISBEE tool

Nomenclature

A	area [m^2]
CA	controlled atmosphere
CFD	computational fluid dynamics
C_p	specific heat capacity [J kg^{-1} K^{-1}]
h	heat transfer coefficient [W m^{-2} K^{-1}]
k	thermal conductivity [W m^{-1} K^{-1}]
m	mass [kg]