A CFD MODELLING SYSTEM FOR AIR FLOW AND HEAT TRANSFER IN VENTILATED PACKING SYSTEMS DURING FORCED-AIR COOLING OF FRESH PRODUCE

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ABSTRACT

Forced-air cooling is the common method for precooling horticultural produce. Ventilated packaging systems are often used to facilitate cooling efficiency. A computational fluid dynamics (CFD) modelling system was developed to simulate airflow and heat transfer processes in the layered and bulk packaging systems during the forced-air cooling of fresh produce.

Airflow and heat transfer models were developed using a porous media approach. The areas inside the packaging systems were categorised as solid, plain air, and produce-air regions. The produce-air regions inside the bulk packages or between trays in the layered packages were treated as porous media, in which the volume-average transport equations were employed. This approach avoids dealing with the situation-specific and complex geometries inside the packaging systems, and therefore enables the development of a general modelling system suitable for a wide range of packaging designs and produce.

The calculation domains were discretised with a block-structured mesh system that was referenced by global and local grid systems. The global grid system specifies the positions of individual packages in a stack, and the local grid system describes the structural details inside individual package. The solution methods for airflow and heat transfer models were based on SIMPLER (Semi-Implicit Method for Pressure-Linked equations Revised) method schemes, and the systems of linear algebraic equations were solved with GMRES (Generalised Minimum Residual) method.

A prototype software package CoolSimu was developed to implement the solution methods. The software package hid the core components (airflow and heat solvers) from user, so that the users without any knowledge of CFD and heat transfer can utilise the software to study cooling operations and package designs. The user interaction components in CoolSimu enable users to specify packaging systems and cooling conditions, control the simulation processes, and visualise the predicted airflow patterns and temperature profiles.

When the predicted and measured product centre temperatures were compared during the forced-air cooling of fresh fruit in several layered and bulk packaging systems, good agreements between the model predictions and experimental data were obtained. Overall, the developed CFD modelling system predicted airflow patterns and temperature profiles with satisfactory accuracy.

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TABLE OF CONTENTS

LIST OF FIGURES

LIST of TABLES