UNIVERSITI PUTRA MALAYSIA

FINITE DIFFERENCE SOLUTION INPREDICTING TEMPERATURE PROFILE FOR CHILLING PROCESS OF MALAYSIAN MACKEREL FISH SLAB

ROZZAMRI ASHARI

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MASTER OF SCIENCE
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By

ROZZAMRI ASHARI

Thesis submitted to the School of Graduate Studies, Universiti Putra Malaysia, in Fulfilment of the Requirement for the Degree of Master of Science

September 2012

To

my father Haji Ashari Haji Abu Hassan,

my mother Hajah Zamruddah Haji Zainal Abidin,

and my wife Norakasha Rusli,

THANK YOU

Abstract of thesis presented to the Senate of Universiti Putra Malaysia
in fulfilment of the requirement for the degree of Master of Science

FINITE DIFFERENCE SOLUTION IN PREDICTING TEMPERATURE PROFILE FOR CHILLING PROCESS OF MALAYSIAN MACKEREL FISH SLAB

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September, 2012

Chair: Assoc. Prof. Badlishah Sham Baharin

Faculty: Food Science and Technology

Chilling is very important to maintain the freshness and quality of fish after harvesting. Chilling will also extend fish shelf life and improve fish marketability. The aim of this study is to develop a mathematical model based on finite difference method to predict the temperature profile generated form the fish subjected to chilling and to optimize the finite difference solution by comparing theoretical data against experimental data.

Experimental work was done by calculating the thermophysical properties of fish such as thermal conductivity, thermal diffusivity, specific heat and mass density. Thermophysical properties value obtained was inserted into the finite difference model. Air blast cooling system was designed to generate the experimental temperature profile. Time-temperature relationship graph obtained from the system was used as reference in the prediction of temperature profile.

For theoretical work, initially the general heat conduction equation was incorporated into the finite difference model. The finite difference model was then converted into a time-temperature relationship graph by plotting points according to the data generated by the finite difference solution. Two types of mathematical approach were used namely the explicit and implicit models. Both explicit and implicit graphs were then compared against experimental graph and analyzed. A combination of explicit-implicit mathematical model was then produced to determine the best weighing factor (β) for finite difference solution which displayed similar time-temperature history graph as the experimental graph.

It was found that temperature decreased rapidly at the surface and decreased subtly at the centre of the fish slab. The point located near the surface showed a decrease from room temperature to 1ºC in 20 minutes whereas the centre point took about 40 minutes. Generally, the implicit model showed more accuracy than explicit model when compared to experimental data. However, the explicit model was able to predict sample 1 time-temperature curve more accurately than the implicit one whereas sample 2 was predicted more accurately by the implicit model. Optimization was done by manipulating the weighing factor (β) and number of nodes (n). The mixture model, a combination of explicit-implicit model showed high accuracy especially with weighing factor, β = 0.6. Accuracy increased up to 40% and the decrease in the predicted temperature range was about ±0.152°C. Number nodes, *n* = 10 displayed the best result with error equals to 0.250 and computation time 20 seconds

Abstrak tesis yang dikemukakan kepada Senat Universiti Putra Malaysia
sebagai memenuhi keperluan untuk ijazah Master Sains

PENYELESAIAN BEZA TERHINGGA BAGI MERAMALKAN PROFIL SUHU UNTUK PROSES PENYEJUKKAN SLAB IKAN TENGGIRI MALAYSIA

Oleh

ROZZAMRI ASHARI

September, 2012

Pengerusi: Prof. Madya Badlishah Sham Baharin

Fakulti: Sains dan Teknologi Makanan

Penyejukan adalah sangat penting bagi memastikan kesegaran dan kualiti ikan selepas ditangkap. Penyejukan juga akan meningkatkan jangka hayat ikan dan kebolehpasaran ikan. Tujuan penyelidikan ini adalah untuk membina sebuah model matematik berdasarkan kaedah beza terhingga untuk meramal profil suhu ikan apabila disejukkan dan mengoptimumkan penyelesaian beza terhingga dengan membandingkan data teori dan data eksperimen.

Eksperimen dijalankan dengan melakukan pengiraan sifat-sifat termofizikal ikan seperti konduksian terma, resapan terma, haba tetap dan ketumpatan jisim. Nilai-nilai sifat termofizikal yang diperoleh dimasukkan ke dalam model beza terhingga. Sistem penyejukan '*air blast'* direka bagi menghasilkan data profil suhu eksperimen. Graf hubungan masa-suhu yang diperolehi digunakan sebagai rujukan bagi meramal profil suhu.

Bagi kajian secara teori, persamaan am konduksi haba telah dimasukkan ke dalam model beza terhingga. Model beza terhingga ini kemudian diolah untuk

menghasilkan graf hubungan masa-suhu dengan memplot titik-titik berdasarkan data yang dihasilkan oleh penyelesaian beza terhingga. Dua jenis pendekatan matematik digunakan iaitu model tersurat dan tersirat. Kedua-dua graf tersurat dan tersirat kemudiannya dibandingkan dengan graf eksperimen dan dianalisis. Gabungan model matematik tersurat-tersirat kemudian dihasilkan untuk menentukan factor penimbang (β) untuk penyelesaian beza terhingga yang terbaik yang menunjukkan graf hubungan masa-suhu yang hampir sama dengan graf eksperimen.

Daripada eksperimen yang dijalankan, didapati suhu menurun dengan mendadak di permukaan dan turun dengan perlahan di bahagian tengah ikan. Titik yang terletak berhampiran dengan permukaan menunjukkan penurunan dari suhu bilik ke 1ºC dalam masa 20 minit manalaka titik tengah pula mengambil masa lebih kurang 40 minit. Secara amnya, model tersirat menghasilkan data yang lebih tepat berbanding dengan model tersurat apabila dirujuk kepada data eksperimen. Namun demikian, model tersurat mampu meramal lengkung suhu-masa bagi sampel 1 lebih jitu dari tersirat manakala sampel 2 diramalkan lebih jitu oleh model tersirat.

Pengoptimuman telah dilakukan dengan memanipulasi faktor penimbang (β) dan bilang nombor nod (*n*). Model percampuran, model gabungan tersurat-tersirat menunjukkan ketepatan yang tinggi dengan nilai faktor penimbang 0.6. Kejituan meningkat sehingga 40% dan ramalan julat suhu telah menurun sebanyak ±0.152°C. Bilangan number nod, n = 10 menunjukkan hasil yang terbaik dengan kesalahan sebanyak 0.250 dan masa komputasi 20 saat.

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In the name of Allah, Most Gracious, Most Merciful. After a long journey undoubtedly laced with His Grace, I have finally reached the finishing line, and that my research on **FINITE DIFFERENCE SOLUTION IN PREDICTING TEMPERATURE PROFILE FOR CHILLING PROCESS OF MALAYSIAN MACKEREL FISH SLAB** has also attained its objectives, and answered each and every experimental questions and problems. Thus, I am hereby proffering my utmost gratitude unto Him for the strength I needed the most to complete this research.

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To my family, and to my wife, Norakasha Rusli, I greatly thank you all for the inspiration, motivation, and moral support throughout this journey. Thank you for loving me and believing in my capabilities. My thanks also go to all staffs of Faculty of Food Science and Technology, UPM, especially those from the Department of Food Technology. Without their kindness and support, this research would not have been an enjoyable ride of learning and discovering new things in life.

THANK YOU

APPROVAL OF EXAMINATION COMMITTEE

I certify that a Thesis Examination Committee has met on **XXth, Month, Year** to conduct the final examination of **Rozzamri Ashari** on his thesis entitled **"Finite Difference Solution in Predicting Temperature Profile for Chilling Process of Malaysian Mackerel Fish Slab"** in accordance with the Universities and University Colleges Act 1971 and the Constitution of the Universiti Putra Malaysia [P.U.(A) 106] 15 March 1998. The Committee recommends that the student be awarded the Master of Science.

Members of the Examination Committee were as follows:

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APPROVAL OF SUPERVISORY COMMITTEE

This thesis was submitted to the Senate of Universiti Putra Malaysia and has been accepted as fulfilment of the requirement for the Degree of Master of Science. Members of the Supervisory Committee were as follows:

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DECLARATION

I declare the thesis is my original work except for quotations and citations which have been duly acknowledged. I also declare that it has not been previously, and is not concurrently, submitted for any other degree at Universiti Putra Malaysia or at any other institution.

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ROZZAMRI ASHARI

Date : 18 September 2012

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