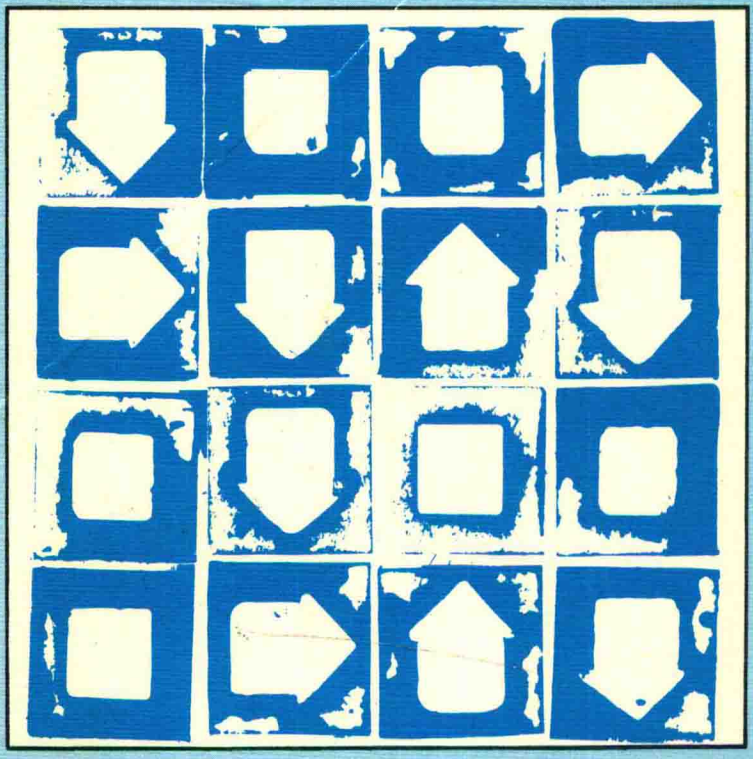
FOOD ENGINEERING AND PROCESS APPLICATIONS

Volume 1

TRANSPORT PHENOMENA

Edited by

M. LE MAGUER and P. JELEN



ELSEVIER APPLIED SCIENCE PUBLISHERS

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TRANSPORT PHENOMENA

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FOREWORD

It was an honour for Canada to serve as host for the 4th International Congress on Engineering and Food. Food engineering and the whole concept of food processing are matters of vital national and international interest. It is fitting that this Congress was held in Edmonton, a city that symbolizes the Canadian spirit and will to achieve.

Governments everywhere cannot ignore the agri-food sector when it comes to laying down national policies. In Canada, 40% of our economic activity is related in some way to our agri-food industry. The 4000 food and beverage processing companies make a significant contribution to this effort.

It has long been acknowledged that research has a crucial role to play in creating national prosperity, through growth and enhanced competitiveness of the industry. Any discussion of food processing research implies transfer of technology. The importance of technology transfer cannot be emphasized enough. It must be a primary concern of all food processors, researchers and engineers. A Canadian example of technology transfer is the development of our edible oil industry. Three decades ago there was no edible oil industry in Canada based on rapeseed. Now, our version of rapeseed, canola, is a major cash crop for domestic processing and export. Nowadays, Canadian canola is a commodity to be reckoned with on the world stage.

It is important for the future of many countries in the world that we move more vigorously than in the past to raise the productive capacity and competitive level of the food processing industry. If we succeed, the world will become less dependent upon raw material exports from producing countries such as Canada. Other countries must take the same approach by focusing on commodities important to them.

The food processing industry in various parts of the world is not an island to itself. It does have a social responsibility to the countries in which it operates. All of us in the food business have a responsibility to feed people who do not have enough to eat. There are no easy solutions to the problems of hunger, but if each country built a strong and dynamic food industry and thereby created jobs, wealth and economic strength, we could end the hunger on this planet. As professionals in the food industry we must not lose sight of our collective responsibility to provide a safe, abundant and wholesome food supply for all, and we must share our knowledge with others. This book is an excellent example of international cooperation and goodwill among the food scientists and engineers who can influence the progress in development of new food processing techniques for tomorrow.

Dr E. J. LeRoux
Assistant Deputy Minister, Research
Agriculture, Canada

PREFACE

The two volumes of *Food Engineering and Process Applications* were assembled from the papers presented at the Fourth International Congress on Engineering and Food held in Edmonton, Canada, in July 1985.

The Congress was organized under the auspices of the Faculties of Agriculture and Engineering of the University of Alberta and the sponsorship of national and international engineering and food science societies. It was supported with major grants from the Natural Sciences and Engineering Research Council of Canada, the Regional Industrial Expansion program of the government of Canada, the Alberta Agriculture Research Council, and the University of Alberta.

This is the third in a series of compilations which have now contributed significantly to the literature in Food Engineering. It presents a broad coverage of basic and applied research subjects dealing with the application of engineering principles to food processing operations. It shows again the evolution of Food Engineering towards a well defined and identifiable field of engineering in its own right and illustrates the vast potential of engineering scientists and industrial researchers to generate new and original information.

Because of the large number of contributions included, it was decided to organize the work in two volumes with distinctly different themes. Volume 1 deals more specifically with basic aspects of physical and transport properties of foods, kinetics and mathematical modeling, selected heat and mass transfer problems and thermal processing and irradiation. Volume 2 is concerned with various unit operations and industrial processes and includes most of the invited symposia papers supplemented with contributions in the areas of Food Freezing,

Extrusion Engineering, Membrane Processing, Genetic Engineering, Energy and Food Processing Operations, or Industrial Engineering and Process Control. Its final section contains a selection of papers addressing the ever present problem of Food Engineering in developing countries. While the selection of the contributions for the respective volumes may appear somewhat arbitrary, it is a result of our deliberate attempt to finish with two approximately equal volumes dealing with the two dominant themes of contemporary Food Engineering—transport phenomena and unit operations.

Although we as editors must assume full responsibility for the final product, we would be remiss not to express our thanks to many of our colleagues listed as the Editorial Board who assisted us with screening the contributions for their technical suitability. Sincere thanks are also due to Dr R. Biswal for helping at different stages of the preparation of the volumes, and finally to our wives, Ivy and Sylva, for constant encouragement and understanding which made our tasks much easier.

M. Le Maguer
P. Jelen

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A FLOOD TIDE FOR BIO-ENGINEERS

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ABSTRACT

Most present day food technologies including milling, baking, brewing, acid fermentations, dehydration and refrigeration are directly derived from ancient domestic crafts. Though the chemist and the microbiologist have significantly contributed to a greater understanding of the nature, composition, protection and preservation of foods and their raw materials, it is the engineer who progressively has replaced human physical labour with machines powered successively by water, wind, steam and electricity. Advances in mechanization have resulted more from perceptive empiricism than from basic scientific principles.

The future calls for a new breed of bio-engineers: men and women capable of developing industrial processes based upon a wide assortment of biological conversions. It requires also scientists of broad and long-sighted vision whose perspective extends beyond the laboratory walls; managers who can comprehend and control the complex biotechnological systems upon which industries of the future will depend.

'There is a tide in the affairs of man
Which when taken at the flood
Leads on to fortune.
On such a full sea we are now afloat
And we must take the current where it serves
Or lose our ventures.'

* The views expressed in this paper are those of the author and not necessarily of the International Development Research Centre.

A flood tide is fast overtaking the world's small community of biological engineers. Whether they float to fortune or sink in sorrow depends upon the philosophy, prescience, perception and persistence they bring to bear upon the opportunities that await them.

'La vie est une fonction chimique' wrote Antoine Lavoisier in 1780. Indeed chemistry has contributed much to the knowledge of food composition and analytical methods by which the consuming public is protected from naturally occurring, adventitious, or intentional adulteration, superfluous sophistication and unwanted contamination of its food. Following Pasteur, microbiologists have identified—and differentiated between—the beneficial and pathogenic microbial species. More recently, physics has helped us to a better understanding of the structure and rheology of food materials and provided the many elegant instruments which are the everyday tools of the analyst and quality control specialist.

Nonetheless, the history of food technology is dominated by engineering: by the replacement of human labour, first by animal and later by machine power. Food engineering can thus be regarded both as a progenitor and a progeny of the Industrial Revolution. Food technology has contributed greatly to the variety, wholesomeness and appeal of the foods available to the world's wealthy nations. But its most evident benefit has been to reduce the human effort needed in the factory, the restaurant and the home.

ORIGINS OF FOOD TECHNOLOGY

Almost all our modern food processing technologies are based upon domestic arts and crafts that have been in existence for a long time. Five thousand years ago Peking man (*Sinanthropus pekinensis*) ground grains, crushed berries and cooked his food. Grain mills, bakeries and breweries existed in the royal courts of Egypt more than 6000 years before Eduard Buchner and Emil Fischer laid the basis for our understanding of the enzymic conversion of carbohydrates in panary and alcoholic fermentation.

Stone Age Britons 3000 years ago oven dried their cereal grains to prevent sprouting during winter storage. Australia's ingenuity in storing cereals grains in 25 000 tonne gas-tight silos under an atmosphere of carbon dioxide generated from dry ice pellets was anticipated by Egyptians and inhabitants of what is now Saudi Arabia more than