Medical Foods from Natural Sources

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To my parents
Late Prabin C. Chakravarty
and
Ms. Sarala Chakravarty

Preface

In the last couple of decades, a revolution has occurred in the area of medical nutrition therapy; particularly, the role of basic and conditionally essential nutrients in the management and treatment of various diseases has received significant attention. As a result, several research articles and books have been published in the area of medical nutrition therapy. Simultaneously, medical foods (enteral foods) have overwhelmingly flooded the global market. In such a situation, a question arises: why to write another book on *Medical Food from Natural Sources?* What is the contribution of this book to medical nutrition therapy?

First, what is new in this book is the development of the medical (enteral) foods from *natural sources*. Because of the prevalent *drug-like approach* to the formulation of medical foods, most of the enteral foods marketed currently are a blend of defined or chemically defined food ingredients. These ingredients lack the natural stimulants and protectants present in normal foods. Further, they are unpalatable and often artificially flavored and excessively sweetened to mask the chemical taste of the ingredients. Furthermore, the defined ingredients-based enteral foods are too expensive for low-income-group patients.

To overcome the aforementioned drawbacks associated with defined ingredients-based enteral foods, this book describes the development of cost-effective enteral foods from natural sources such as barley, rice, mung bean, eggs, milk, etc. True, the preparation of nutrient-dense liquid foods from the natural food ingredients that can flow easily through feeding tube can be a difficult task for the scientists. To overcome this difficulty, this book suggests the use of malted cereals and grain legumes as bases for the preparation of enteral foods. This is where this book offers a unique contribution to the *food-like approach* to develop *medical foods*, which is an alternative to conventional *drug-like* approach.

Second, to the best of my knowledge, none of the published books in medical nutrition therapy offer information relating to the developmental aspects of enteral foods. These aspects play a critical role in overall acceptability, tolerance, and effectiveness of enteral nutrition support. Therefore, this book fills this prominent gap in the literature by addressing in detail the developmental aspects of enteral foods.

In sum, this book encourages the readers to combine the principles of food science with food technology to develop a cost-effective enteral nutrition support to the

patients. I sincerely hope that this research-based information will spark new ideas in the readers interested in the development of *medical food from natural sources*. Your comments are most welcome at dr_mkaur@hotmail.com.

Winnipeg, Canada Meera Kaur

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Note on the Author

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Contents

List of Figures

List of Tables

List of Abbreviations

AAA	Aromatic Amino Acids
AACC	American Association for Clinical Chemistry
AAS	Amino Acid Score
AF	Aluminium Foil Laminate
ARF	Amylase Rich Food
AOAC	Association of Official Agricultural Chemists
BC	Before Christ
BCA	Bacillus Cereus Selective Agar
BCAA	Branched Chain Amino Acids
BMR	Basal Metabolic Rate
BPA	Bisphenol A [2, 2-bis(4-hydroxyphenyl)] Propane
BSA	Bovine Serum Albumin
BSS	British Standard Specification
BUN	Blood Urea Nitrogen
BV	Biological Value
CMI	Cell Mediated Immunity
COPD	Chronic Obstructive Pulmonary Diseases
cP	Centipoises Unit
Cmm	Cubic Millimetre
DEF-BP	Disease-specific Enteral Food for Burn Patient
DHA	Docosahexaenoic acid
DMSO	Dimethylsulphoxide
DNS	Dinitrosalicylic acid
DS	Dextrose Starch
Dwb	Dry Weight Basis
EAA	Essential Amino Acids
EDTA	Ethylene-Diamine-Tetra-Acetic acid
EFA	Essential Fatty Acids
EMB	Eosin Methylene Blue Agar
EN	Enteral Nutrition
EPA	Eicosapentaenoic Acid

FALCA	Food Allergen Labeling and Consumer Protection Act
FAO	Food and Agriculture Organization
FFA	Free Fatty Acid
FFDCA	Federal Food, Drug, and Cosmetic Act
g	gram
GEF-LC	General-Category Low-Cost enteral food
GEF-RT	General-Category Ready-To-eat enteral food
GIT	Gastro-Intestinal Tract
GLC	Gas Liquid Chromatography
GPC	Gel Permeation Chromatography
GRAS	Generally Recognized as Safe
h	Hour
Hb	Hemoglobin
HCV	Hepatitis C Virus
HI	Humoral Immunity
HTST	High Temperature Short-Time Treatment
IBD	Irritable Bowel Disease
IgA	Immunoglobulin A
IGFBP	Insulin-like Growth Factor Binding Protein
IgG	Immunoglobulin G
IgM	Immunoglobulin M
ISI	Indian Standard Institution
IU	International Unit
IV	Intravenous
kcal	Kilocalorie(s)
Kd	kilodalton.
KF	Kang-Fung
kg	Kilogram(s)
LCEF	Low Cost General-Category Enteral Food
LTST	Low Temperature and Short Time
LAB	Lactic Acid Bacteria
LMIT	Lymphocyte Migration Inhibition Test
MCH	Mean Corpuscular Hemoglobin
MCHC	Mean corpuscular hemoglobin concentration
MCV	Mean Corpuscular Volume
MCT	Medium-Chain Triglycride
ME	Mercaptoethanol
MEq:	Millieqivalent
MIT	Migration Inhibition Test
MoDC	Monocyte-derived Dendritic Cells (MoDC)
μg	Microgram
mg.	Milligram

ml.	Milliliter
MP	Metallised Polyester
MRS	Mann-Rogosa-Sharpe
MTH	Methylhistidine
MUG	4-Methylumbelliferyl-Beta-D-Glucuronide
NASA	National Aeronautics and Space Administration
NG	Nasogastric Feeding
NPR	Net Protein Ratio
NPU	Net Protein Utilization
OTR	Oxygen Transmission Rate
PCV	Packed cell volume
PDA	Potato Dextrose Agar
PDCAAS	Protein Digestibility Corrected Amino Acid Score
PEF	Proprietary Enteral Food
PEG	Percutaneous Endoscopic Gastrostomy
PEJ	Percutaneous Endoscopic Jejunostomy
PER	Protein Efficiency Ratio
PHA	Phytohemagglutinin
PN	Parenteral Nutrition
PUFA	Poly Unsaturated Fatty Acids
RBC	Red Blood Cells
RSL	Renal Solute Load
SDS	Sodium Dodecyl Sulfate Polyacrylamide Gel Electrophoresis
SEM	Scanning Electron Microscopic
SGOT	Serum Glutamic Oxaloacetic Transaminase
SGPT	Serum Glutamic Pyruvic Transaminase
SSA	Salmonella Shigella Agar
TBSA	Total Burn Surface Area
TD	True Digestibility
TLC	Total lymphocyte count
TPC	Total Plate Count
TPN	Total Parenteral Nutrition
WBC	White Blood Cells
WSI	Water Solubility Index
WVTR	Water Vapor Transmission Rates

Chapter 1
Introduction

Introduction

Proper nutritional support to patients improves their responsiveness to the medical treatment, reduces morbidity and mortality, and cuts the hospitalization costs significantly. There are two kinds of nutrition support – parenteral and enteral. Parenteral nutrition support is effective and lifesaving, but its prolonged use is not desirable because it fails to preserve gut functions and integrity. However, when the gastrointestinal tract is not functional, parenteral nutrition support (i.e., feeding sterile nutrients via vein, thereby bypassing the gut) still remains as an alternative method of nutritional support. By contrast, enteral nutrition support (feeding food orally or via a tube to the gut) is an effective method to provide nutritional support to patients who have a functional or partially functional gastrointestinal tract but are unable to nourish themselves effectively. Enteral nutrition support has gained significant importance over parenteral nutrition, because it preserves intestinal structure and functions. Further, it is cost effective, easy to administer and manage. This book is designed to contribute to effective nutrition support to patients by developing the enteral food from natural sources.

Enteral foods are a class of liquid medical foods that are engineered to provide complete or partial enteral nutritional support to the patients. These foods are delivered either orally or through a tube directly to the stomach, duodenum, or jejunum, depending upon the medical condition of the patient. Although several enteral foods are available in the market, most of them are based on either defined or chemically defined ingredients wherein maltodextrin, glucose, or fructose serve as sources of carbohydrates; sodium or calcium caseinate, amino acids or protein hydrolysates as sources of protein; and, soy oil, corn oil, medium chain triglycerides, or structured lipids as sources of lipid. These defined or chemically defined ingredients are expensive and lack the natural stimulants and protectants that are present in the natural foods. Further, to mask the off flavor of defined ingredients, these foods often need to be artificially flavored. Furthermore, some of the defined ingredients do exert high osmotic load causing diarrhea or dehydration.

To overcome the aforementioned issues, this book explains the process for the development of a range of cost-effective enteral foods, akin to normal wholesome

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diet, from *natural food* ingredients. Controlled clinical trials carried out on burn patients and case studies conducted on patients suffering from various diseases confirmed better acceptability and tolerance of the natural ingredients-based enteral foods than defined ingredients-based formulae. In addition to providing optimal nutritional support, natural ingredients based-enteral foods were cost effective compared with defined ingredients-based enteral foods. Clearly, it is worthwhile to disseminate the *new* knowledge and *in*expensive technology for the development of enteral food from natural sources to the intellectual community. Certainly, application of this technology will contribute significantly to the nutritional management of patients around the world while reducing the total costs of patient care system.

Given the importance of enteral nutrition in medical sciences, several books have been published relating to enteral nutrition support. But most of these published books focus *only* on the issues such as rationale for enteral nutrition support, specific nutrient requirements for various disease conditions, practical approaches to the delivery, and monitoring and prevention of complications while providing enteral nutrition support. None of them offers information relating to the developmental aspects of enteral foods (e.g., processing technology, types of ingredients, physicochemical and nutritional characteristics, and shelf-life evaluations, among others). These aspects are critical because they affect the overall acceptability, tolerance, and effectiveness of enteral nutrition support. Therefore, a need was felt to fill the gaps in the literature by addressing the developmental aspects of enteral foods in detail, such as processing technologies, physicochemical quality evaluation of processed ingredients and the formulations based on them, shelf-life evaluation, and clinical outcome studies of natural ingredients-based enteral foods.

Hence, the purpose of writing this book is to communicate the novel technology for developing enteral foods from natural sources, discuss the results of the clinical trials conducted in various categories of patients, and evaluate the efficacy of the natural ingredients-based enteral foods. This research-based book addresses the aforementioned issues and serves the need of patients in both developed and developing countries through this inexpensive yet effective enteral nutrition support.

Ideally, the book has been written for postgraduate and research students. However, some aspects of this book will serve the upper level undergraduate students. Also, this book is intended for researchers, scientists, medical fraternity, or anybody who is interested in advancing knowledge in the area of enteral foods and enteral nutrition support. Because this book covers two different yet related areas – Food science and Technology, and Clinical Nutrition – it caters two sets of audiences.

From *Food Science and Technology* viewpoint, this book has been written at postgraduate level making it suitable for students, scientists, or researchers in the area of food science, grain science and technology, milling technology, sensory sciences, and dairy technology, among others. This book explains various food processing technologies such as how to a prepare enzyme-rich, fiber-regulated flour from cereals and grain legumes suitable for enteral foods; resist the coagulation characteristics of heat-treated eggs making them suitable for enteral-tube feeding; incorporate live probiotics and active bacterial cultures in enteral and other