

SARAHMED EDITIONS

**Contact us by e-mail at leseditionssarahmed@gmail.com or visit
our website <https://sarahmed.net/>**

ISBN 978-9969-677-07-2

May 2026

Nutrition and Functional Nutrition

Dr Nabila BRAHMI-CHENDOUEH

TABLE OF CONTENTS

GENERAL INTRODUCTION	1
1. HUMAN NUTRITION: EVOLUTION, DIETARY TRANSITION AND PUBLIC HEALTH CHALLENGES	5
1.1. EVOLUTION OF HUMAN NUTRITION	5
1.2. FROM TRADITIONAL DIETS TO WESTERN DIETS	7
1.3. INCREASE IN DIET-RELATED DISEASES	8
1.4. NUTRITION AS A CROSS-CUTTING DISCIPLINE	10
1.5. PHYSIOLOGICAL, BEHAVIOURAL AND ECOLOGICAL PERSPECTIVES	12
2. NUTRIENT NEEDS, BALANCED DIET AND DIET QUALITY	14
2.1. NUTRIENT REQUIREMENTS AND RECOMMENDED INTAKES	14
2.2. ENERGY DENSITY AND NUTRIENT DENSITY	16
2.3. BALANCED DIET AND DIETARY BALANCE	18
2.4. MACRONUTRIENTS AND MICRONUTRIENTS: ROLES AND INTAKE PRINCIPLES	20
2.5. DIET QUALITY INDICATORS AND PRACTICAL GUIDANCE	23
2.6. MINI CASE STUDY: APPLYING NUTRIENT NEEDS AND DIET QUALITY PRINCIPLES	25

3. MALNUTRITION, FOOD SECURITY AND VULNERABILITY	27
3.1. FOOD SECURITY, NUTRITION SECURITY AND FOOD-AND-NUTRITION SECURITY	27
3.2. VULNERABILITY AND POPULATIONS AT RISK	28
3.3. MALNUTRITION: UNDERNUTRITION, OVERNUTRITION AND HIDDEN HUNGER	30
3.4. CAUSES OF UNDERNUTRITION: IMMEDIATE, UNDERLYING, AND ROOT CAUSES	32
3.5. CONSEQUENCES OF MALNUTRITION ACROSS THE LIFE COURSE	34
4. NUTRITION INTERVENTIONS AND PUBLIC HEALTH STRATEGIES	37
4.1. NUTRITION EDUCATION	37
4.2. NUTRITION-SENSITIVE AGRICULTURE AND FOOD SYSTEMS	38
4.3. SOCIAL PROTECTION AND SCHOOL-BASED INTERVENTIONS	40
4.4. WATER, SANITATION AND HYGIENE (WASH)	41
4.5. HEALTH-SYSTEM INTERVENTIONS	42
4.6. NUTRITION IN EMERGENCIES	44
5. DIETARY ASSESSMENT AND NUTRITIONAL STATUS	46
5.1. HOUSEHOLD AS A UNIT OF ASSESSMENT	46
5.2. HOUSEHOLD FOOD CONSUMPTION AND DIVERSITY	47
5.3. INDIVIDUAL DIETARY DIVERSITY	48
5.4. FOOD CONSUMPTION SURVEYS AND TOOLS	49
5.5. NUTRITIONAL COMPOSITION OF FOODS	52
5.6. ASSESSMENT OF WOMEN AND NEWBORN NUTRITIONAL STATUS	53

6. FOOD CLASSIFICATION, TYPOLOGY AND DIETARY USE	57
6.1. WHY FOODS ARE CLASSIFIED	57
6.2. DIVERSITY OF CLASSIFICATION SYSTEMS	58
6.3. THE SEVEN MAJOR FOOD CATEGORIES	59
6.4. PROCESSED AND ULTRA-PROCESSED FOODS	61
6.5. PRACTICAL USE OF FOOD GROUPS IN NUTRITION EDUCATION	63
7. FUNCTIONAL FOODS AND NUTRACEUTICALS: CONCEPTS AND DEFINITIONS	65
7.1. DEFINITIONS AND TERMINOLOGY	65
7.2. DIFFERENCES BETWEEN FUNCTIONAL FOODS, NUTRACEUTICALS AND DIETARY SUPPLEMENTS	66
7.3. HISTORICAL DEVELOPMENT	68
7.4. COMPARATIVE REGULATORY OVERVIEW (JAPAN, EU, USA, CANADA)	69
8. BIOACTIVE COMPOUNDS AND MECHANISMS OF ACTION	77
8.1. FIBRES, PREBIOTICS AND PROBIOTICS	77
8.2. POLYPHENOLS, CAROTENOIDS AND ANTIOXIDANTS	79
8.3. OMEGA-3 FATTY ACIDS, PHYTOSTEROLS AND BIOACTIVE LIPIDS	81
8.4. ISOFLAVONES, SULFUR COMPOUNDS AND OTHER PHYTOCHEMICALS	83
8.5. MECHANISMS: ANTIOXIDANT, ANTI-INFLAMMATORY, METABOLIC AND MICROBIOTA-RELATED EFFECTS	85

9. MAJOR CATEGORIES OF FUNCTIONAL FOODS	89
9.1. FUNCTIONAL DAIRY PRODUCTS	89
9.2. FUNCTIONAL CEREALS AND FIBRE-ENRICHED FOODS	90
9.3. FUNCTIONAL BEVERAGES	92
9.4. FORTIFIED FOODS AND ENRICHED FOODS	94
9.5. FUNCTIONAL FRUITS, VEGETABLES AND PLANT-BASED PRODUCTS	95
10. HEALTH APPLICATIONS AND SCIENTIFIC EVIDENCE	98
10.1. CARDIOVASCULAR HEALTH	98
10.2. OBESITY, DIABETES AND METABOLIC SYNDROME	100
10.3. GASTROINTESTINAL HEALTH AND GUT MICROBIOTA	101
10.4. BONE HEALTH AND MENOPAUSE	103
10.5. CANCER PREVENTION: EVIDENCE AND LIMITS	105
10.6. HOW TO INTERPRET SCIENTIFIC EVIDENCE AND LEVELS OF PROOF	106
11. SAFETY, QUALITY CONTROL AND HEALTH CLAIMS	109
11.1. SAFETY ASSESSMENT AND DOSAGE ISSUES	109
11.2. QUALITY CONTROL OF FUNCTIONAL INGREDIENTS	111
11.3. STABILITY, PROCESSING AND BIOAVAILABILITY	113
11.4. LABELLING AND HEALTH CLAIMS	115
11.5. ETHICAL ISSUES, MISINFORMATION AND CONSUMER PROTECTION	118

12. INNOVATION, MARKET TRENDS AND FUTURE PERSPECTIVES	120
12.1. CONSUMER PERCEPTION AND ACCEPTANCE	120
12.2. PRODUCT DEVELOPMENT AND INNOVATION PATHWAYS	122
12.3. PERSONALIZED NUTRITION AND FUTURE TRENDS	123
12.4. SUSTAINABILITY AND FUNCTIONAL FOOD DEVELOPMENT	125
REFERENCES	128

General introduction

Nutrition is the science that examines how foods, nutrients, and other biologically active constituents interact with digestion, metabolism, physiology, growth, reproduction, immunity, and long-term health across the life course. In contemporary public health and food science, nutrition can no longer be reduced to the prevention of classic deficiency diseases alone; it is equally concerned with diet quality, excess energy intake, chronic non-communicable diseases, food safety, and the broader social and ecological conditions that shape what populations eat. Recent WHO guidance emphasizes that healthy diets are simultaneously defined by adequacy, balance, moderation, diversity, and safety, and that their composition must be interpreted in relation to age, activity, culture, and local food availability rather than by a single universal menu (World Health Organization [WHO], 2026; World Health Organization & Food and Agriculture Organization of the United Nations [FAO], 2024).

The continuing centrality of nutrition is explained by the coexistence of multiple, overlapping forms of malnutrition. At the global level, hunger, micronutrient inadequacy, overweight, obesity, and diet-related non-communicable diseases now occur within the same countries, communities, households, and sometimes the same individuals, generating what is often described as a complex and interdependent burden of malnutrition. The 2025 edition of *The State of Food Security and Nutrition in the World* reports that the world remains off track for Sustainable Development Goal 2, while recent global analyses likewise indicate insufficient progress toward the 2030 nutrition targets and persistent deficiencies in essential micronutrients across large population groups, especially women, infants, adolescents, and low-

income populations (FAO et al., 2025; Global Nutrition Target Collaborators, 2024; Passarelli et al., 2024).

These nutritional challenges are inseparable from the global nutrition transition, a term that refers to the progressive shift from traditional dietary patterns toward diets richer in refined starches, added sugars, unhealthy fats, sodium, energy-dense commercial products, and highly processed foods. WHO notes that rapid urbanization, changing lifestyles, and transformations in food production and food systems have altered dietary behaviors in ways that frequently reduce fibre intake and displace minimally processed foods. Recent reviews in *Nature Medicine* further show that Western-style diets are linked to gut microbial rarefaction, chronic low-grade inflammation, and elevated risk of obesity, type 2 diabetes, cardiovascular disease, liver disorders, and some cancers, illustrating that dietary change is not only cultural and economic but also mechanistically relevant to disease pathogenesis (Adolph & Tilg, 2024; WHO, 2026).

For these reasons, modern nutrition places increasing emphasis on the quality of the whole diet rather than on isolated nutrients considered in abstraction from foods and dietary patterns. Diet quality refers to the extent to which habitual intake aligns with evidence-based principles for nutrient adequacy, food variety, proportionality among food groups, moderation of harmful components, and overall metabolic suitability. Systematic review evidence shows that diet quality indices can capture meaningful dietary change when they reflect the pattern being promoted, while newer work also indicates that diet quality is increasingly being evaluated alongside environmental and affordability dimensions, because healthier diets are desirable only insofar as they are feasible, culturally acceptable, and sustainable in real food systems (Conrad et al., 2025; McAuley et al., 2023; WHO & FAO, 2024).

An adequate understanding of nutrition therefore requires movement across levels of analysis, from nutrients and metabolism to households, food environments, food systems, and population vulnerability. Nutritional status is shaped not only by physiological requirements but also by purchasing power, intra-household food allocation, care practices, sanitation, disease exposure, agricultural conditions, market prices, and the informational environment in which consumers interpret foods and claims. The persistence of unaffordable healthy diets, unequal exposure to food insecurity, and widespread micronutrient gaps demonstrates that assessment tools must be able to detect both biological risk and social inequality, linking dietary data to public-health action rather than treating food intake as an isolated behavioral variable (FAO et al., 2025; Passarelli et al., 2024; WHO, 2026).

Within this broader scientific landscape, functional nutrition has emerged as a particularly dynamic field. Functional nutrition extends classical nutrition by examining how foods and food matrices can contribute physiological benefits beyond basic energy and essential nutrient supply, especially through fibres, phytochemicals, probiotics, prebiotics, bioactive lipids, and other components capable of modulating oxidative stress, inflammation, metabolic regulation, gut microbiota, and cell signaling. The growing interest in functional foods reflects both advances in food science and a preventive-health paradigm in which diet is expected to support health maintenance and risk reduction; however, this field also requires careful distinction between naturally functional foods, fortified or enriched foods, nutraceuticals, and dietary supplements, because these categories differ in formulation, evidence base, technological constraints, and intended use (Essa et al., 2023).

The scientific and commercial expansion of functional foods also raises important regulatory and ethical questions. Claims that a food or one of its constituents improves a physiological function, reduces a disease risk factor, or provides a specific nutritional advantage must be supported by robust evidence, communicated in a non-misleading manner, and evaluated within the legal framework of each jurisdiction. EFSA highlights that foods bearing nutrition or health claims are expected to satisfy relevant nutritional requirements and that the purpose of nutrient profiling is to prevent consumers from being misled by selective claims on otherwise nutritionally poor products. In the United States, the FDA distinguishes among health claims, nutrient content claims, and structure/function claims, a differentiation that is central to consumer protection, labeling practice, and responsible product development (European Food Safety Authority [EFSA], n.d.; U.S. Food and Drug Administration [FDA], 2024).

This book is designed in response to that scientific complexity. It moves from the foundations of human nutrition and diet quality, through malnutrition, food security, interventions, dietary assessment, and food classification, toward the concepts, mechanisms, categories, health applications, safety issues, and future directions of functional foods and nutraceuticals. Its central objective is to provide Bachelor-level students in Agri-Food Technology and Quality Control with a coherent framework that connects biochemical principles, physiological mechanisms, public-health reasoning, food technology, quality assurance, regulatory interpretation, and innovation. In that sense, the manuscript treats nutrition and functional nutrition not as separate domains, but as contiguous parts of a single evidence-based discipline concerned with how foods can nourish populations, prevent harm, and contribute to healthier and more sustainable food systems (Adolph & Tilg, 2024; Essa et al., 2023; FAO et al., 2025; WHO & FAO, 2024).