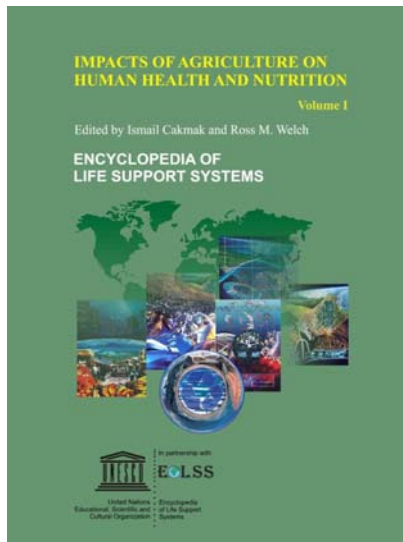


# CONTENTS

## IMPACTS OF AGRICULTURE ON HUMAN HEALTH AND NUTRITION



### **Impacts of Agriculture on Human Health and Nutrition - Volume 1**

**No. of Pages:** 506

**ISBN:** 978-1-84826-093-1 (eBook)

**ISBN:** 978-1-84826-543-1 (Print Volume)

### **Impacts of Agriculture on Human Health and Nutrition - Volume 2**

**No. of Pages:** 314

**ISBN:** 978-1-84826-094-8 (eBook)

**ISBN:** 978-1-84826-544-8 (Print Volume)

For more information of e-book and Print Volume(s) order, please [click here](#)

[Or contact : eolssunesco@gmail.com](mailto:eolssunesco@gmail.com)

## CONTENTS

### VOLUME I

#### **Agricultural and Molecular Genetic Approaches to Improving Nutrition and Preventing Micronutrient Malnutrition Globally** 1

Ismail Cakmak, *Faculty of Engineering and Natural Sciences, Sabanci University, Turkey*  
Robin D. Graham, *Plant Sciences Department, University of Adelaide, Waite Campus, Australia*  
Ross M. Welch, *USDA-ARS, US Plant, Soil, and Nutrition Laboratory, Ithaca, New York, USA*

1. Introduction
  - 1.1. Agriculture, the Availability of Micronutrients, and Health
    - 1.1.1. Micronutrient Requirements
    - 1.1.2. Changing Cropping Systems: Unforeseen Consequences of the "Green Revolution"
  - 1.2. Extent of Micronutrient Malnutrition Globally
  - 1.3. Consequences of Micronutrient Malnutrition
    - 1.3.1. Health Consequences
    - 1.3.2. Societal and Development Consequences
  - 1.4. Historical Approaches to Eliminating Micronutrient Malnutrition
2. Genetic Modification of Food Crops for Improved Bioavailable Micronutrient Density
  - 2.1. Traditional Plant Breeding Opportunities
    - 2.1.1. Wheat
    - 2.1.2. Rice
    - 2.1.3. Maize
    - 2.1.4. Bean
    - 2.1.5. Cassava
  - 2.2. Using Molecular Genetics and Unique Plant Genes to Increase Density and Improve Bioavailability
    - 2.2.1. Use of Molecular Markers in Screening for Micronutrient Efficiency
    - 2.2.2. Genetic Engineering
  - 2.3. Antinutrient and Promoter Substances Affecting Micronutrient Bioavailability
    - 2.3.1. Phytic Acid
    - 2.3.2. Tannins
    - 2.3.3. Carotenoids
    - 2.3.4. Sulfur-Containing Amino Acids
3. The Importance of Using Holistic Food-Based Approaches to Finding Sustainable Solutions to Micronutrient Malnutrition
4. Conclusions

#### **Global Prevalence of Micronutrient Malnutrition and Impacts on the Health of Children** 43

P. Bratter, *Department of Trace Elements in Health and Disease, Hahn-Meitner-Institut Berlin, Germany*  
V. E. Negretti de Bratter, *Department of Trace Elements in Health and Disease, Hahn-Meitner-Institut Berlin, Germany*

1. Introduction
2. Micronutrient Deficiency States
3. Micronutrients and Deficiency Disorders of the Malnourished Child
  - 3.1. Iron Deficiency Anemia
  - 3.2. Vitamin A Deficiency
  - 3.3. Iodine deficiency disorders
  - 3.4. Selenium Deficiency Disorders
  - 3.5. Zinc Deficiency Disorders
  - 3.6. Folate Deficiency
4. Global Aspects of Childhood Malnutrition
5. Malnutrition during Child Development
  - 5.1. The Term Infant

- 5.2. Pre-Term Infants
- 5.3. Adolescents
6. Infant Feeding
  - 6.1. Breast-feeding
  - 6.2. Daily Trace Element Intakes from Breast Milk and Formulas and Comparison with Recommended Intake Values
  - 6.3. Human Milk vs. Infant Formula
  - 6.4. Maternal HIV-Infection and Infants Nutrition
7. Conclusions

### **Iron Nutrition in Man: Global Perspectives on Iron Deficiency and Malnutrition**

**62**

Hambraeus, L., *Dept. of Medical Science and Nutrition, Uppsala University, Uppsala, Sweden*

1. Introduction
2. Two Concepts of Malnutrition
3. Iron Deficiency- A Global Problem of Public Health Importance
  - 3.1. Definition of Various Forms of Iron Deficiency
  - 3.2. Prevalence of Iron Deficiency
  - 3.3. The Cost of Iron Deficiency
  - 3.4. Iron Deficiency in Low-Income Countries
  - 3.5. Iron Deficiency in Industrialised Countries
4. Iron Forms in the Body
5. Studies on Iron Nutrition – A Methodological Challenge
6. Iron Deficiency Tests
7. Physiological Effect of Iron Deficiency.
8. Bioavailability
9. The Iron Intake Paradox
10. Iron Malnutrition - A Result of Deteriorating Nutrient Density or Energy Density?
11. Iron Deficiency and Excess - A Public Health Dilemma
12. Dietary Diversification, Changes in Food Preparation or Food Supplementation?
13. Calcium-Iron Interaction

### **Global Importance of Zinc Deficiency in Humans: Its Relation to Malnutrition and Strategies for Its Prevention**

**81**

Gibson, R.S. *,Department of Human Nutrition, University of Otago, Dunedin, New Zealand*

1. Introduction
2. Etiology of Zinc Deficiency in Developing Countries
  - 2.1. Low Intakes and Poor Bioavailability of Dietary Zinc
  - 2.2. Excessive Losses
  - 2.3. High physiological requirements
3. Prevalence and consequences of zinc deficiency
  - 3.1. Zinc, Growth, and Body Composition
  - 3.2. Zinc and Reproduction
  - 3.3. Zinc and Immune Competence
  - 3.4. Zinc and Neurosensory Function
  - 3.5. Zinc and Mental, Psychomotor and Cognitive Development
4. Strategies to Prevent Zinc Deficiency in Developing Countries
  - 4.1. Supplementation
  - 4.2. Fortification
  - 4.3. Dietary Modification/Diversification
    - 4.3.1. Increase Zinc Content of Staple Foods
    - 4.3.2. Increase the Zinc Content of Diets
    - 4.3.3. Alter Content of Absorption Modifiers in Staple Foods
    - 4.3.4. Alter Content of Absorption Modifiers in Diets

**Global Importance of Selenium and Its Relation to Human Health**

**98**

Gerald F. Combs Jr., *Division of Nutritional Sciences, Cornell University, Ithaca, NY 14853, USA*

1. Introduction
2. Metabolic Roles of Selenium
3. Selenium in Food Systems
  - 3.1. Fundamental Importance of Soil Selenium
  - 3.2. Selenium Cycle
  - 3.3. Selenium in Plant Materials
  - 3.4. Selenium in Animal Products
  - 3.5. Selenium in Human Diets
  - 3.6. Selenium Bioavailability
4. Global Variation in Selenium Status
5. Selenium and Human Disease
  - 5.1. Selenium Deficiency Disorders
  - 5.2. Keshan Disease
  - 5.3. Kaschin-Beck Disease
  - 5.4. Iodine Deficiency Diseases
  - 5.5. Selenium Status and Other Diseases
  - 5.6. Selenium Status and Malnutrition
6. Selenium as an Anti-Carcinogen
  - 6.1. Background
  - 6.2. Clinical Trial Results
  - 6.3. Mechanisms of Selenium Anti-Carcinogenesis
7. Selenosis
8. Enhancing Selenium in Food Systems
  - 8.1. Selenium as a Resource Input
  - 8.2. Production of Selenium-Enriched Foods
9. Conclusions

**Global Importance of Vitamin A Deficiency in Humans and its Relationship to Malnutrition**

**118**

C. A. N. Clewes, *Northern Ireland Centre for Diet and Health (NICHE), University of Ulster, Coleraine BT52 1SA, Northern Ireland, UK*

D. I. Thurnham, *Northern Ireland Centre for Diet and Health (NICHE), University of Ulster, Coleraine BT52 1SA, Northern Ireland, UK*

1. Definitions
  - 1.1. Vitamin A
  - 1.2. Carotenoids
  - 1.3. Units of Measurement
2. Vitamin A deficiency (VAD)
  - 2.1. Clinical Deficiency
  - 2.2. Sub-Clinical Deficiency
    - 2.2.1. Functional Indicator
    - 2.2.2. Liver Stores
    - 2.2.3. Serum/Plasma Retinol
    - 2.2.4. Breast Milk
    - 2.2.5. Histology
    - 2.2.6. Ecological Factors
3. The present situation of VAD globally
4. Malnutrition and vitamin A deficiency in infancy
5. Vitamin A and childhood mortality and morbidity
  - 5.1. Vitamin A and Infection
  - 5.2. Malnutrition, Vitamin A Deficiency and Measles Mortality
  - 5.3. Malaria and Vitamin A
6. Vitamin A and morbidity

- 6.1. Vitamin A and Diarrheal Disease
- 6.2. Vitamin A and Respiratory Disease
- 6.3. Human Immunodeficiency Virus (HIV), Acquired Immunodeficiency Syndrome (AIDS) and Vitamin A
- 6.4. Vitamin A and Epithelial Integrity
7. Maternal VAD
  - 7.1. Breast-Feeding
  - 7.2. Complementary Weaning Foods
  - 7.3. Anemia and Vitamin A
8. Global commitment
  - 8.1. Supplementation
    - 8.1.1. Universal Distribution
    - 8.1.2. High-Risk Groups
    - 8.1.3. Maternal Supplementation
    - 8.1.4. Absorption and Retention
    - 8.1.5. Monitoring and Evaluation of Supplementation
    - 8.1.6. Cost and Sustainability
  - 8.2. Dietary improvement
  - 8.3. Fortification of Foods
9. Conclusions

**Experience with Environmental Supplementation of Iodine in Irrigation Water as a Practical Agricultural Approach to Reduce Iodine Deficiency** **146**  
 DeLong, G. R., *Department of Pediatrics, Duke University Medical Center, Durham, North Carolina, USA*

1. Introduction
2. Basic Pathophysiology and Manifestations
3. Geology and Geography of Iodine Deficiency
4. Monitoring and Measurement: Indices of Iodine Deficiency
5. Methods of Iodine Supplementation
6. Iodine and Livestock
7. Agricultural Approach to Iodine Supplementation
8. An Experiment in Environmental Supplementation of Iodine Through Irrigation Water
9. Results of Iodate Dripping into Irrigation Water in Southern Xinjiang
10. Effect of Iodine Supplementation on Infant Mortality
11. A proposal for iodination of animals in pastoral economies

**Community-Centered Food-Based Strategies for Alleviating and Preventing Malnutrition** **162**  
 Thompson, B. , *Senior Nutrition Officer, Food and Nutrition Division, Food and Agriculture Organization, Italy*

1. Introduction
  - 1.1. What is FAO and what it does?
  - 1.2. The International Conference on Nutrition (ICN)
  - 1.3. World Food Summit (WFS)
  - 1.4. Community-centered Food-Based Approach
2. Nutritional Status and its Determinants
  - 2.1. Definitions of Malnutrition and Household Food Security
  - 2.2. The Current and Projected Food and Nutrition Situation
3. The Role of Agriculture for Alleviating and Preventing Malnutrition
  - 3.1. Developing an Enabling Policy Environment
  - 3.2. Appropriate Macro-Economic Framework
  - 3.3. Agricultural Policies
  - 3.4. Population Concerns
  - 3.5. Environmental Concerns and Sustainable Agriculture

4. Improving the Nutritional Impact of Food and Agriculture Based Strategies
  - 4.1. Increasing Food Production
  - 4.2. Increasing Access to Foods
  - 4.3. Increasing and Maintaining the Nutrient Content of Foods
  - 4.4. Improving the Nutrient Content of the Diet
  - 4.5. Increasing the Consumption of a Nutritionally Adequate Diet
5. Community-centered Food-Based Strategies for Improving Nutrition
6. Conclusions

**Improving the Nutritional Quality of Maize and Wheat for Human Consumption 210**

Long, J. , *School of Public Health, University of California-Los Angeles, USA*

Ortiz-Monasterio, J. I. , *Wheat Program, CIMMYT, Mexico*

Banziger, M. , *Maize Program, CIMMYT, Zimbabwe*

1. Introduction
2. Micronutrient Malnutrition in Maize and Wheat Growing Areas
  - 2.1. Impact and Prevalence of Micronutrient Malnutrition
  - 2.2. Population Impacts on Land Usage
  - 2.3. Diet Composition
3. The Potential Role of Micronutrient-Dense Maize and Wheat Staples
  - 3.1. Wheat Statistics
  - 3.2. Maize Statistics
  - 3.3. Variety Development
  - 3.4. Seed Distribution
4. Education
5. Conclusions
6. Technical Appendix: Breeding Strategies for Micronutrient-Dense Maize
  - 6.1. Genetic Variability
    - 6.1.1. Maize
    - 6.1.2. Wheat
  - 6.2. Traits that Confer Micronutrient Density
    - 6.2.1. Maize
    - 6.2.2. Wheat
  - 6.3. Current Breeding Efforts
    - 6.3.1. Maize
    - 6.3.2. Wheat

**Improving Micronutrient Value of Rice Through Breeding 231**

Gregorio, G. B. , *Plant Breeding, Genetics and Biochemistry Division, IRRI, DAPO Box 7777, Metro Manila, Philippines*

Senadhira, D. , *Plant Breeding, Genetics and Biochemistry Division, IRRI, DAPO Box 7777, Metro Manila, Philippines*

Htut, T. , *Plant Breeding, Genetics and Biochemistry Division, IRRI, DAPO Box 7777, Metro Manila, Philippines*

Graham, R. D. , *Department of Plant Science, University of Adelaide, Glen Osmond 5064, South Australia, Australia*

1. Introduction
2. Rice and Micronutrients
  - 2.1. Variability in Iron and Zinc Content in Rice Grain
3. Effect of Soil and Climate on Grain Mineral Content
4. Optimal Growing Conditions and Mineral Concentration
5. Effect of Milling on Grain Iron Content
6. Improved Rice with Enhanced Fe and Zn in the Grain
7. Bioavailability Tests
8. Mapping and Genetics of high-Fe Trait in the Grain

- 8.1. Mapping Genes for High-Fe and -Zn Traits
- 8.2. Genetic Analysis of high-Fe Trait
- 9. Breeding Strategy
- 10. The Future

**Improvement of Common Bean for Mineral Nutritive Content at CIAT**

**248**

Beebe, S. , *Bean Program, CIAT, Cali, Colombia*

- 1. Introduction
- 2. Consumption of Legumes
  - 2.1. The Importance and Role of Legumes in Diets
  - 2.2. Bean Consumption and Global Micronutrient Needs
- 3. Genetic Resources of Bean
- 4. Aspects of Mineral Nutrition as Applied to Bean
  - 4.1. Mineral Concentration
  - 4.2. Environmental Effects on Concentration
  - 4.3. Amino Acid Concentration
  - 4.4. Anti-nutrients
    - 4.4.1. Variability in Tannin Concentration
    - 4.4.2. Phytates in Bean
- 5. Genetics of Mineral Concentration
  - 5.1. Segregation Patterns
  - 5.2. QTL Analysis of Iron and Zinc Concentration
- 6. Implementation in Breeding Programs

**Classical Breeding to Improve Vegetable Vitamin and Provitamin Content**

**263**

M. E. N. Fonseca, *Centro Nacional de Pesquisa de Recursos Genéticos & Biotecnologia (CENARGEN) – Empresa Brasileira de Pesquisa Agropecuária (EMBRAPA), Brasília-DF, Brazil.*

J. P. Navazio, *Alf. Christianson Seed Co., Mount Vernon, Washington, USA*

P.W. Simon, *USDA-ARS, Department of Horticulture, University of Wisconsin-Madison, Wisconsin, USA.*

- 1. Introduction
  - 1.1. Vegetables as a Source of Vitamins
  - 1.2. The Importance of Selection for Vitamin Content in Vegetable Breeding Programs
- 2. Breeding Efforts to Improve Vitamin or Provitamin Content in Vegetable Crops
  - 2.1. Provitamin A Carotenoids
    - 2.1.1. Breeding Carrots for Carotene Content
    - 2.1.2. Breeding Sweet Potatoes for Carotene Content
    - 2.1.3. Breeding Peppers (Capsicum) for Carotene Content
    - 2.1.4. Breeding Tomatoes for Carotene Content
    - 2.1.5. Breeding Watermelon for Carotene Content
    - 2.1.6. Breeding Melons for Carotene Content
    - 2.1.7. Breeding Pumpkins and Squash of Cucurbita pepo for Carotene Content
    - 2.1.8. Breeding Pumpkins and Squash of Cucurbita maxima for Carotene Content
    - 2.1.9. Breeding Pumpkins and Squash of Cucurbita moschata for Carotene Content
    - 2.1.10. Breeding Cucumbers for Carotene Content
    - 2.1.11. Breeding Cauliflower and Broccoli (Brassica oleracea L.) for Carotene Content
    - 2.1.12. Breeding Other Vegetables for Carotene Content
  - 2.2. B Complex Vitamins
    - 2.2.1. Breeding Table Beets for Folate Content
  - 2.3. Vitamin C
  - 2.4. Vitamin E
- 3. Future Direction and Conclusions

**The Economics of Plant Breeding as an Agricultural Strategy for Reducing Micronutrient Malnutrition**

**283**

Bouis, H. E. , *International Food Policy Research Institute, 2033 K St., N.W., Washington, D.C. 20006, USA*

1. Introduction
2. Micronutrient Malnutrition: Extent, Costs, Alternative Interventions
3. Can A Breeding Strategy Work? Five Key Questions
  - 3.1. Is it scientifically feasible to breed for staple food varieties whose seeds are micronutrient-dense?
  - 3.2. What effect will breeding for micronutrient-dense seeds have on plant yields? Will farmers adopt such varieties?
  - 3.3. Will breeding for micronutrient-dense seeds change the processing or consumer characteristics of staple foods?
  - 3.4. Will micronutrient intakes be increased to a significant degree? To what extent will the extra micronutrients in staple foods consumed be bioavailable?
  - 3.5. Are there other lower-cost, more easily sustainable strategies for reducing micronutrient malnutrition?
4. Conclusions

**Influence of Mineral Fertilizers on Nutritional Quality of Staple Food Crops**

**303**

Wiesler, F. ,*Institute of Plant Nutrition, University of Hannover, Germany*

Gerendas, J. ,*Institute of Plant Nutrition and Soil Science, University of Kiel, Germany*

Sattelmacher, B. , *Institute of Plant Nutrition and Soil Science, University of Kiel, Germany*

1. Introduction
  - 1.1. Properties Determining Plant Quality
  - 1.2. Factors Controlling Plant Quality
2. Selected Examples Demonstrating the Influence of Mineral Fertilizers on Nutritional Quality of Crops
  - 2.1. Minerals
    - 2.1.1. Concentration of Essential Minerals of Particular Concern
      - 2.1.1.1. Calcium and Magnesium
      - 2.1.1.2. Iron and Zinc
      - 2.1.1.3. Selenium and Iodine
    - 2.1.2. Concentration of Potentially Toxic Minerals
    - 2.1.3. Bioavailability of Minerals
  - 2.2. Nitrogenous Compounds
    - 2.2.1. Proteins
      - 2.2.1.1. Protein Concentration
      - 2.2.1.2. Amino Acid Composition
      - 2.2.1.3. Protein Digestibility and Utilization
    - 2.2.2. Potentially Toxic Nitrogenous Compounds
  - 2.3. Carbohydrates (Saccharides)
  - 2.4. Lipids
  - 2.5. Vitamins
    - 2.5.1. Vitamin A
    - 2.5.2. Vitamin C (Ascorbic acid)
    - 2.5.3. Vitamin B complex
    - 2.5.4. Niacin
  - 2.6. Bioactive Substances
    - 2.6.1. Carotenoids
    - 2.6.2. Sterols
    - 2.6.3. Saponins
    - 2.6.4. Glucosinolates
    - 2.6.5. Sulfides
    - 2.6.6. Polyphenols



3. Conclusions

<b>Agronomic Approaches for Increasing Iron Availability to Food Crops</b>	<b>339</b>
<i>Chen, Y. , Department of Soil and Water Sciences, Faculty of Agricultural, Food and Environmental Quality Sciences, The Hebrew University of Jerusalem, Rehovot 76100, Israel</i>	
<i>Shenker, M. , Department of Soil and Water Sciences, Faculty of Agricultural, Food and Environmental Quality Sciences, The Hebrew University of Jerusalem, Rehovot 76100, Israel</i>	

1. Introduction - The Origin and Scope of the Problem
2. Agronomic Methods for Correction of Iron Deficiency
  - 2.1. General Considerations
  - 2.2. Historical Review
  - 2.3. Iron Fertilizers
    - 2.3.1. Inorganic Fe Fertilizers
    - 2.3.2. Industrial By-Products
    - 2.3.3. Synthetic Iron Chelates
    - 2.3.4. Iron-Organo Complexes
  - 2.4. Soil Management
    - 2.4.1. Soil Acidification
    - 2.4.2. Aeration
    - 2.4.3. Antagonistic Nutrients Management
  - 2.5. Rhizosphere Manipulation
  - 2.6. Foliar Applications
  - 2.7. Genetic Improvement of Fe-Efficiency in Plants
  - 2.8. New Agronomic Approaches

<b>Agronomic Approaches to Increasing Zinc Concentration in Staple Food Crops</b>	<b>363</b>
<i>Rengel, Z. , Soil Science and Plant Nutrition, University of WA, 35 Stirling Highway, Crawley WA 6009, Australia</i>	

1. Introduction
2. Variation in Zn Concentration in the Grain
3. Variation in Zn Concentration in Root Crops
4. Effects of Macronutrient Fertilizers in Increasing Zn Concentration in Staple Food Crops
5. Effects of Zn Fertilizers in Increasing Zn Concentration in Staple Food Crops
  - 5.1. Soil Application of Zn Fertilizers
  - 5.2. Foliar Application of Zn Fertilizers
  - 5.3. Other Ways of Increasing Zn Supply to Crops
    - 5.3.1. Growing Crops from Seed with High Total Zn Content
    - 5.3.2. Seed Soaking and Seed Coating Prior to Sowing
    - 5.3.3. Mycorrhizae
    - 5.3.4. Organic Matter
    - 5.3.5. Sewage Sludge
    - 5.3.6. Lime
6. Cropping systems
  - 6.1. Crop and Variety Selections
  - 6.2. Genotypes Differing in Zn Efficiency
  - 6.3. Crop Rotations
7. Soil Mining: Fact or Fallacy
8. Remobilization of Zn from Vegetative Tissues for Loading into the Grain
9. Conclusions

**Agronomic Approaches to Increase Selenium Concentration in Livestock Feed and Food Crops** **383**

Gissel-Nielsen, G. , *Risoe National Laboratory, Denmark*

Gupta, U.C. , *Crops and Livestock Research Centre, AAFC, Charlottetown, PE, Canada*

1. Introduction
2. Geographic distribution of Se
3. Se uptake by plants
4. Field treatment with Se
  - 4.1. Soil Application
  - 4.2. Foliar Application
  - 4.3. Seed Treatment with Selenium
  - 4.4. Experience on a Larger Scale
  - 4.5. Main Guidelines
5. Bioavailability of Se
6. Conclusion

**Agricultural Practices to Minimize Nitrate Accumulation in Edible Parts of Crop Plants** **398**

Schenk, M. K. , *Institute of Plant Nutrition, Department of Horticulture, University of Hannover, Germany*

1. Introduction
2. Hazards of Nitrate to Health
  - 2.1. Methemoglobinemia
  - 2.2. Cancer
  - 2.3. Threshold Values
3. Nitrate in Plants
  - 3.1. Nitrate Reduction
  - 3.2. Osmotic Regulation
  - 3.3. Nitrate Content
4. Control of Nitrate Content of Plants
  - 4.1. Environmental Conditions
    - 4.1.1. Light
    - 4.1.2. Temperature
  - 4.2. Nitrogen Fertilization
    - 4.2.1. Fertilizer Rate
    - 4.2.2. Organic Farming
    - 4.2.3. Nitrogen Form
    - 4.2.4. Chloride
    - 4.2.5. Soil-less Culture
  - 4.3. Crop Production Management
    - 4.3.1. Variety
    - 4.3.2. Harvesting
  - 4.4. Food Preparation

**Index** **417**

**About EOLSS** **425**

## VOLUME II

**Plant Based Sources of Proteins and Amino Acids in Relation to Human Health** **1**

Millward, D.J. , *Director, Centre for Nutrition and Food Safety, University of Surrey, Guildford, Surrey, UK*

1. Introduction

2. Protein Quantity
  - 2.1. Digestibility
  - 2.2. Amino Acid Composition and Biological Value
    - 2.2.1. Direct Measurement of Biological Value
3. Difficulties in Defining Amino Acid Requirements and Protein Scoring Patterns
  - 3.1. Identification of a Scoring Pattern for Protein Quality Evaluation
4. Adequacy of Plant Based Diets in Developing Countries for Children.
5. Health Implications of Plant Protein Diets
  - 5.1. Are Their Benefits from Lower Intakes of Indispensable Amino Acids of Plant Based Diets?
  - 5.2. Are There Benefits from Lower Protein Intakes of Plant Based Diets?
  - 5.3. Increased Delivery of Nitrogen to the Lower Gut from Poorly Digested Plant Proteins
  - 5.4. Influences of Specific Peptide Sequences of Plant Proteins
  - 5.5. Presence of Phytoprotectant Factors
6. Conclusions

**Molecular Genetic Approaches to Improve the Nutritional Quality of Staple Food Crops 20**

Chavez-Barcenas, T. , *Centro de Investigacin y Estudios Avanzados del I.P.N (CINVESTAV) Irapuato, Gto., Mexico*

Nieto-Jacobo, M.F. , *Centro de Investigacin y Estudios Avanzados del I.P.N (CINVESTAV) Irapuato, Gto., Mexico*

Simpson, J. , *Centro de Investigacin y Estudios Avanzados del I.P.N (CINVESTAV) Irapuato, Gto., Mexico*

Herrera-Estrella, L. , *Centro de Investigacin y Estudios Avanzados del I.P.N (CINVESTAV) Irapuato, Gto., Mexico*

1. Introduction
2. Crop Improvement
  - 2.1. Genetic Engineering
    - 2.1.1. Identification of Genes with Potential to Improve the Nutritional Quality of Plants
    - 2.1.2. Introduction of Foreign Genes into Plant Cells
3. Major Biotechnological Advances in Nutritional Improvement of Plants
  - 3.1. Carbohydrates
  - 3.2. Proteins
    - 3.2.1. Enriched Proteins
    - 3.2.2.
    - 3.2.3. Engineering of Free Amino Acids
  - 3.3. Lipids
  - 3.4. Vitamins
    - 3.4.1. Fat-soluble Vitamins
    - 3.4.2. Carotenoids
  - 3.5. Minerals
  - 3.6. Nutraceuticals
    - 3.6.1. Carbohydrates
    - 3.6.2. Carotenoids
    - 3.6.3. Vitamin E
4. Conclusions

**Molecular Genetic Improvement of Protein Quality in Maize**

**60**

Olsen, M. S. *Wilson Genetics, L.L.C., Harlan, Iowa, USA*

Phillips, R. L. , *Department of Agronomy and Plant Genetics and Plant Molecular Genetics Institute, University of Minnesota, St. Paul, Minnesota, USA*

1. Introduction
2. Maize Seed Proteins
3. Genetic manipulation of maize kernel protein fractions
  - 3.1. Molecular Genetic Manipulation of opaque-2 and Quality Protein Maize (QPM)

- 3.2. Investigation of the High-Methionine Inbred Line BSS53
4. Conclusions and Future Prospects

**Molecular Breeding of Vegetable Crops for Improved Provitamin A Carotenoid Content 80**

Fonseca, M. E.N. ,*Centro Nacional de Pesquisa de Recursos Genéticos & Biotecnologia (CENARGEN) EMBRAPA, Brasília-DF, Brazil*

Simon, P.W. , *USDA-ARS, Department of Horticulture, University of Wisconsin-Madison, USA*

1. Introduction
  - 1.1. Biological Importance of Plant Carotenoids
  - 1.2. Nutritional Importance of Plant Carotenoids
2. Molecular Approaches to Improve Carotenoid Content in Vegetable Crops
3. The Carotenoid Biosynthetic Pathway: Enzymes, Genes and Gene Regulation
  - 3.1. Isopentenyl Pyrophosphate (IPP) Formation
  - 3.2. Isomerization of IPP
  - 3.3. Synthesis of Geranylgeranyl Pyrophosphate (GGPP)
  - 3.4. Synthesis of Phytoene
  - 3.5. Desaturation of Phytoene
  - 3.6. Cyclization of Lycopene
  - 3.7. Xanthophyll Formation
  - 3.8. The Hydroxylases:
  - 3.9. Epoxidase and De-epoxidase:
4. Regulation of Carotenoid Biosynthesis in Chloroplast and Chromoplast Development
5. Future Directions and Conclusions

**Genetic Improvement of Cereals with Low Phytic Acid Content 97**

Raboy, V. , *USDA-ARS, Aberdeen, Idaho USA*

1. Introduction
2. Phytic acid Genetics
  - 2.1. Background
  - 2.2. The Isolation of Cereal low phytic acid Mutants
3. Breeding and evaluation of "low phytic acid" crops
4. The Use of Near-Isogenic Crop Lines in Studies of Dietary Phytate in Human Health
5. Conclusions and Future Directions

**Improving the Protein Content and Quality of Temperate Cereals: Wheat, Barley and Rye 118**

Shewry, P.R. , *Long Ashton Research Station, University of Bristol, UK*

1. Introduction
  - 1.1. Cereal Grain Proteins
  - 1.2. Cereal Prolamins
2. Increasing Total Grain Protein
3. Improving Grain Amino Acid Composition
  - 3.1. High Lysine Mutants
  - 3.2. Increasing Free Amino Acids
  - 3.3. Transformation with Genes for High Quality Proteins
4. Conclusion

**Development of Iron-Rich Crops by Genetic Engineering 138**

Yoshihara, T. , *Department of Bio-Science, Central Research Institute of Electric power Industry, Japan*

Goto, F. , *Department of Bio-Science, Central Research Institute of Electric power Industry, Japan*

Masuda, T. , *Department of Bio-Science, Central Research Institute of Electric power Industry, Japan*

Takaiwa, F. , *Department of Cell Biology, National Institute of Agrobiological Resources, Japan*

1. Introduction

2. Overview of the Genetic Improvement for Iron Content in Crops
3. Research Approaches to Understand Molecular Mechanisms Ensuring the Store of Excess Iron in Plants
4. The Advantage to Use the Ferritin Molecule to Store Iron
5. Overproduction of Ferritin in Rice Grain Regulation of Specific Expression
6. A Practical Way to Improve Iron Accumulation Based on Ferritin
  - 6.1. Chimeric Gene Construction and Transformation into Rice, Lettuce and Tobacco
  - 6.2. Accumulation of Soybean Ferritin in Rice Seeds and Lettuce and Tobacco Leaves
  - 6.3. Enrichment of Iron Content in the Transformants
  - 6.4. Estimation of the Practical Value of the Iron Rich Transformants
7. Future work - To Store More Iron in Ferritin and Ensure the Bio-Availability of Iron

### **Engineering of Seed Quality Characters in Legumes**

**155**

Müntz, K. *Institut für Pflanzengenetik und Kulturpflanzenforschung (IPK), Corrensstr. 3, D-06466 Gatersleben, Germany*

1. Introduction
2. The Context Principle
3. The Engineering of High-Methionine Grain Legumes
  - 3.1. What Do We Know About Amino Acid Composition and Major Proteins in Legume Seeds to be Engineered?
  - 3.2. Strategies to Engineer High Methionine Grain Legumes
    - 3.2.1. Strategies A and B: Engineering of High-Methionine Storage Globulins of Grain Legumes
    - 3.2.2. Strategy C: Engineering of Foreign Methionine-Rich Proteins into Seeds of Grain Legumes
    - 3.2.3. Strategy D: Engineering of Pathways of Amino Acid Biosynthesis to Raise the Methionine Content of Grain
    - 3.2.4. Combination of Strategies C and D
  - 3.3. Conclusions Concerning the Engineering of High Methionine Grain Legumes
4. Quantitative Lowering of Nutritionally Adverse Compounds and the Elimination of Toxins
5. Phytofarming for Improved Quality Characters in Grain Legumes Seeds
  - 5.1. Enzyme Production in Legume Seeds
  - 5.2. Phytofarming of Antigens and Antibodies in Legume Seeds

### **Nutritional Consequences of Using Organic Agricultural Methods in Developing Countries**

**181**

K. Brandt, *Department of Horticulture, Danish Institute of Agricultural Sciences, Denmark*  
 U. Kidmose, *Department of Horticulture, Danish Institute of Agricultural Sciences, Denmark*

1. Introduction
  - 1.1. Definitions of Organic Agriculture
  - 1.2. Organic Agricultural Methods
2. Organic Agriculture Methods in Developing Countries
  - 2.1. Plant Residues and Animal Manure
  - 2.2. Catch Crops and Agroforestry
  - 2.3. Crop Diversity
3. Effects of Organic Farming on Nutritional Value of Food Crops
  - 3.1. Protein Content, Essential Amino Acids
  - 3.2. Micronutrients
    - 3.2.1. Effects of Recycling of Organic Material
    - 3.2.2. Effects of Catch Crops on Retention of Microelements in Topsoil
    - 3.2.3. Effects of Imbalance of Plant Nutrients
  - 3.3. Vitamins
    - 3.3.1. Vitamin C
    - 3.3.2. Vitamin A (Carotenoids)
    - 3.3.3. Thiamine and other B-vitamins

- 3.4. Anti-nutritional Factors
  - 3.4.1. Plant defence compounds
  - 3.4.2. Nutrient Storage Compounds (Phytate)
- 3.5. Absence of Pesticide Residues and Excess Nitrate
- 4. Effects of Crop Diversity on Nutritional Value
  - 4.1. Staple Crops and Pulses
  - 4.2. Vegetables and Fruit
  - 4.3. Agroforestry, Nutritional Consequences of Cooking
- 5. Research Needs

**Influence of Organic and Conventional Farming Systems on Nutritional Quality of Food 210**

U. Kopke, *Institute of Organic Agriculture, University of Bonn, Germany*

- 1. Introduction
- 2. Undesirable Ingredients Food Safety
  - 2.1. Plant Products
    - 2.1.1. Pesticide Residues
    - 2.1.2. Nitrate
    - 2.1.3. Heavy Metals and Environmental Contaminants
    - 2.1.4. Mycotoxins
  - 2.2. Animal Products
    - 2.2.1. Pesticides and Contaminants
    - 2.2.2. Veterinary Drugs and Residues in Animal Feeds
    - 2.2.3. Bovine Spongiform Encephalopathy (BSE)
- 3. Desirable Ingredients
  - 3.1. Plant Products
    - 3.1.1. Dry Matter Content
    - 3.1.2. Protein
    - 3.1.3. Carbohydrates
    - 3.1.4. Vitamins
    - 3.1.5. Minerals
    - 3.1.6. Taste, Fragrance and Secondary Plant Substances
  - 3.2. Animal Products
- 4. Holistic Quality Assessment
  - 4.1. Feeding Experiments
  - 4.2. Post-harvest Behavior
  - 4.3. Picture-Forming Methods
- 5. Models
- 6. Effects on Well-being other than Physical or Chemical
- 7. Conclusions

**Developing Sustainable Horticultural Production Systems for Socioeconomic and Nutritional Development in Asia 239**

Ali, M. , *Asian Vegetable Research and Development Center, Shanhua, Tainan, Taiwan*

- 1. Introduction
- 2. General Information
  - 2.1. Current Status of Vegetables in Asia
  - 2.2. Problems in Vegetable Production
    - 2.2.1. Irregular Supply
    - 2.2.2. Seasonal Supply
    - 2.2.3. Production and Marketing Constraints
  - 2.3. Vegetable Groups
  - 2.4. Agroecological Zones and Vegetable Production
- 3. Vegetable Production Systems
  - 3.1. Systems Based on the Proximity to Consumption Centers

- 3.1.1. Peri-Urban Production System
- 3.1.2. Home Gardening
- 3.1.3. Trucking System
- 3.2. Intensity Based Production system
- 4. Diversification of Cereal-based System with Horticulture Crops
  - 4.1. Benefits of Diversification
  - 4.2. Possibilities and Limitations to Diversification
- 5. Vegetable Research Focus
  - 5.1. Year Round Intensive Vegetable Production System Program
    - 5.1.1. Peri-urban System in the Lowlands
    - 5.1.2. Home Garden
    - 5.1.3. Intensive System in the Highlands
  - 5.2. Cereal-based Vegetable System
    - 5.2.1. Legumes in the Cereal-based System
    - 5.2.2. Vegetables in the Cereal-based System
- 6. Successful Examples

**Index** **269**

**About EOLSS** **275**