Integrated Food Science and Technology for the Tropics

Macmillan
INTERNATIONAL
COLLEGE
EDITIONS

A. I. Ihekoronye and P. O. Ngoddy

Integrated Food Science and Technology for the Tropics

Alfred I. Ihekoronye B.Sc. M.Sc. Ph.D.
Department of Food Science and Technology
University of Nigeria, Nsukka

Patrick O. Ngoddy, B.Sc. M.Sc. Ph.D.
Professor of Food Engineering and Processing
Department of Food Science and Technology
University of Nigeria, Nsukka

MACMILLAN
PUBLISHERS

First published 1985

Published by *Macmillan Publishers Ltd*
London and Basingstoke
Associated companies and representatives in Accra, Auckland, Delhi, Dublin, Gaborone, Hamburg, Harare, Hong Kong, Kuala Lumpur, Lagos, Manzini, Melbourne, Mexico City, Nairobi, New York, Singapore, Tokyo

ISBN 0 – 333 – 38883 – 6

Printed in Hong Kong

Acknowledgements

The authors and publishers wish to acknowledge, with thanks, the following photographic sources:-
J. Allan Cash pp 63 right; 137; 251; 354; 255
Barnaby's p 138
Biophoto Associates pp 15; 107; 108; 128
Birds Eye Wall's Ltd. pp 157; 352
Anne Bolt pp 97; 245 top
A. J. Brooks pp 194; 238 bottom
Jim Brownbill pp 56; 74; 143 bottom; 144; 147; 171; 197; 209; 264
Camerapix Hutchison p 5
Camera Press pp 3 top; 308
Central Office of Information, London p 167
Courtaulds Ltd. p 290
FAO pp 12 (photo J. Van Acker); 21 (photo C. Bavagnoli); 47 (photo Maya Bracher); 55 top (photo Ray Witlin); 64 (photo Maya Bracher); 79 (photo J. Van Acker); 115; 126; 151 (photo F. Mattioli); 198 (photo J. Van Acker); 238 centre (photo R. Bridge); 239; 245 bottom (photo F. Botts); 252 (photo F. Mattioli); 253; 261 (photo Ray Witlin); 328; 329 (photo J. Van Acker); 334; 337; 340 (photo F. Mattioli); 243 (photo P. Morin); 248; 360 (photo M. Dessibourg) 272 top right (photo F. Botts); 272 bottom (photo A. Defever); 287; 288 (photo I. Pattinson); 301 (photo G de Sabatino); 315 bottom
Middle East Pictures and Publicity, photographs
Christine Osborne pp 84 right; 113; 259
Rex Parry pp 27; 61; 268; 272 top; 278; 279; 292; 321
Dr. Radley p 311
Alan Thomas cover photograph
Professor Don Tindall p 280
Tropix Photographic Library pp 95; 99; 238 top
UAC International pp 78; 143 top
UNILEVER PLC pp 41; 125; 130; 193
USDA p 63 left; 305
Van den Berghs and Jurgens Ltd. pp 81; 156
WHO pp 3 bottom; 90; 92 (photo Z. Mandelmann); 211 (photo A. Vollan); 212; 241 (photo Paul Almasy);
World Bank p 84 left (photo Hilda Bijur)

The publishers have made every effort to trace the copyright holders, but if they have inadvertently overlooked any, they will be pleased to make the necessary arrangements at the first opportunity.

£10.95

Integrated Food Science and Technology
for the Tropics

Acknowledgements

The authors are extremely grateful for the assistance provided by the International Development Research Centre (IDRC), Ottawa Canada, and by many others in producing this book. A complete listing would cover many pages, and could not possibly be complete, for memory fails as the times roll by. Special appreciation however is expressed to the University of Alberta, Edmonton, Canada for making the library and computing facilities available to us. General assistance and direction can be traced back to the following people who will always be a part of this book:

Ruth Groberman, CIDA, Ottawa Canada
Louise Rohonczy, IDRC, Ottawa Canada
J. Allan Rix, IDRC, Ottawa Canada
Dale Olchowy, Computing Centre, University of Alberta
Sally Vogel, IDRC, Edmonton Alberta
Dr. M.E. Bailey, University of Missouri, Columbia

Last, but not least, we gratefully thank Professor G.R. Howat for reviewing our manuscript, and our editors at Macmillan for working with us in this endeavour.

A.I.I.
P.O.N.

Contents

Introduction

CHAPTER 1

Food science and food technology in developing countries

Data from the United Nations' Food and Agricultural Organisation continue to sound notes of warning that Third World countries, particularly in Africa and the Carribean, should take drastic steps to increase their food production. That unless efforts are geared towards increased food production which to date is grossly inadequate, hunger and malnutrition will sweep through populations with their attendant unwelcome consequencies (Figure 1.1).

Shockingly, but perhaps not surprisingly, many countries in Africa, Asia and Latin America become too preoccupied with unhealthy political rivalries to engage in meaningful agricultural enterprises, and food production trends do not indicate the likelihood of many of these nations being able to grow, process and preserve their own foods. It is both discouraging and disappointing that African leaders in particular and leaders of states in Third World countries in general, when they gather, as they often do, hardly discuss the food problem. Who are they leaving it for? And what should take priority over the food programme when every year thousands of Africans and other Third World citizens join the starvation and malnutrition line-up? We, the food scientists from Third World countries must go beyond politics and do something to provide food and the knowledge necessary to provide food for our people. In this book we will attempt to do so.

Food science and technology, a field embodying the application of modern science and engineering to the production, processing, diversification, preservation and utilisation of food is probably not sufficiently appreciated or understood in the Third World. A number of factors have combined to this end: firstly the extensive identification of food production, processing and preservation with 'home economics', a discipline which has so

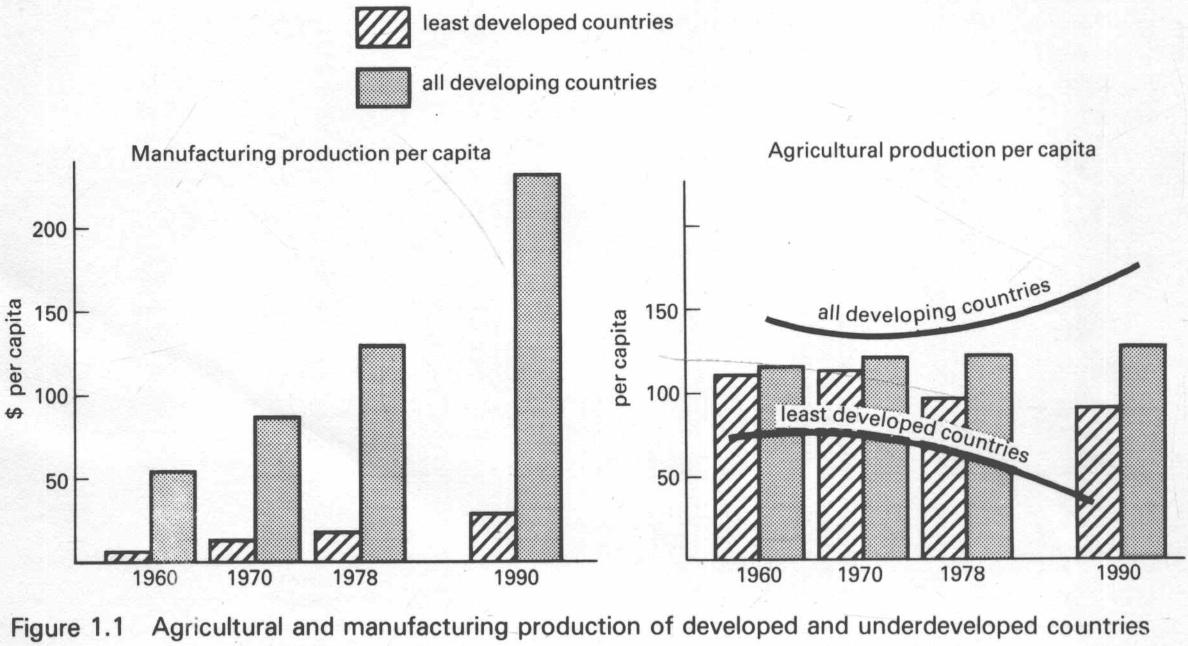
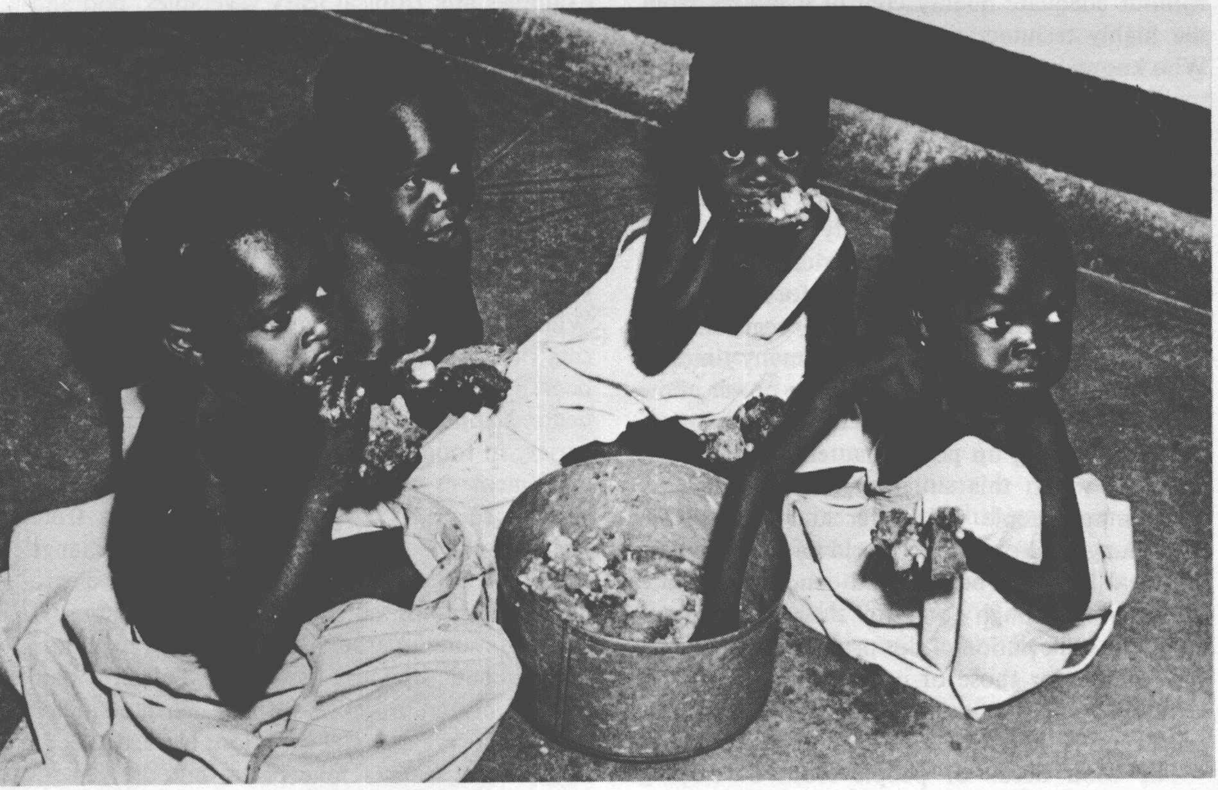


Figure 1.1 Agricultural and manufacturing production of developed and underdeveloped countries

Famine victims in a relief camp await the distribution of food

far failed to make the desired impact in most countries of the Third World where it has been introduced; secondly, the failure to introduce food science and technology as an academic discipline in the curriculum of schools in developing countries; thirdly, and with few notable exceptions, neglect by the food industry and governments to provide the aid which should be given to support research in food related areas; and finally lack of funds or the use of available funds for trivial or prestigious projects instead of applying it to relevant food production projects. But what do food scientists and technologists do?

Food scientists are responsible in seeing that the crop harvested, the fish caught, the animal slaughtered, the egg laid, and the milk produced reach the consumer in the most acceptable, nutritious, safe and wholesome condition. By carefully studying the chemical complexities of foods, their vulnerability to spoilage, their disease vectors and varying sources of production, food scientists endeavour to accomplish this formidable task. They try to eliminate seasonal gluts and shortages, providing a technologically sound base for the



Health education programmes in many countries teach mothers to provide a varied diet for their children to prevent malnutrition levelling out of food surpluses and shortages within and among countries and regions. The applications of genetic engineering in crop production and the trappings of farm mechanisation in all its paraphernelia are the offensive weapons utilised in modern agriculture to increase productivity. An effective processing and preserving tradition is the defensive rear guard. This tradition lies in the domain of food science and technology. The remedy for the malady of post-harvest losses in food grains in the highly industrialised societies has been the development, along with increase in yield potential, of adequate storage and low-cost processing technologies to preserve and store the harvest. The development and production of new nutritious foods to improve the diet of people suffering from malnutrition, the provision of adequate group-specific diets for the young and adults performing under conditions of stress, pregnant and lactating mothers, kwashiorkor and diabetic patients exemplify some of the accomplishments in this direction. Who knows how many people from developing countries have died from eating bloated canned foods imported without adequate quality control measures from the highly technocratic and advanced societies? Who knows how many have died from consuming toxicants naturally occurring in food-stuffs?

Food is very essential to man's survival, and great attention should be paid to food production, distribution, wholesomeness and preservation. Given the resources – especially land and man power – available to many African and Third World nations, one finds no reason for much of the poverty and hunger within these regions. But leaders from developing countries many times in their selfish and insatiable desire for power allow political considerations to override good judgement in drawing up policy matters. As we food scientists watch this situation, we wonder how many more people will suffer and perhaps die from hunger before Third World nations talk less and deal less with politics and concentrate more on growing enough food for their teeming populations. Alleviation of this problem is not only a way of life for those of us in food science and technology but also the foundation on which our profession is built.

The food needs of people from developing countries are not different from those of the developed world. They are simply needs for at least the minimum requirements of six groups of nutrients:

Carbohydrates a source of calories or energy.
Examples are: edible aroids, yams, cassava, sweet potatoes, plantains, arrowroot, breadfruit, sago, cereals and sugar plants

Fats a source of energy.
Examples are: palm oil, coconut oil, animal fat, tropical nuts, melon seeds, fish oil, butter, margarine

Proteins used for growth, tissue maintenance and repair, may also be used to provide energy.
Examples are: meats, insects, eggs, fish, milk, legumes, nuts and seeds

Vitamins regulate body processes.
Examples are: tropical leafy vegetables, pod and seed vegetables, root vegetables, fruits, seaweeds

Minerals regulate body processes, some used for growth and replacement of tissue.
Examples are: tropical leafy vegetables, pod and seed vegetables, root vegetables, fruits, seaweeds

Water for control of body processes.
The main sources of water are: potable water, tropical fruits and leafy vegetables

But it should also be recognised that man, and indeed all other animals respond to the sensory stimuli of foods, i.e. to their organoleptic value. Where food is abundant and the choice wide, man eats first for palatability and then for nutritional benefit. More food of greater organoleptic or hedonic appeal is eaten and a greater diversity and variety in foods chosen when socio-economic improvement is combined with both increasing abundance of foods and variety of foods from which to choose. The kinds of food eaten change from a predominantly cereal and root tuber diet to one that contains more animal products, more fat and more simple carbohydrates, such as sugar and sugar products. There is a change from home milled cereals to more refined machine-milled ones. There are national variations in the degree to which such changes take place, but the general trend is almost universal and represents the fulfillment of a need to enjoy more and better food when such can be afforded (Tables 1.1 and 1.2).

For low income people in developing countries animal products representing protein of high concentrations and quality are either too expensive or simply unavailable and the bulk of the diet in these areas is composed of cereal grains or starchy root and tuber crops. Rice, corn, sorghum, millet and wheat, the more common cereal grains, have protein contents of only 7–15 per cent, and less if they are milled. Banana, plantain, yam and cassava are the staple part of the diet in many developing countries, and their protein content is substantially less than that of cereals. This situation denies the people a well-balanced diet which is necessary for the maintenance of good health.

In some parts of Africa, Asia and Latin America, there is shortage of vitamin A which results eventually in blindness. Pellagra is still found in some parts of the tropics where people live largely on maize. Beri-beri is common among people eating polished rice. Nutritional anaemia due to iron deficiency is the chief cause of maternal and infant mortality in many developing countries. In areas where the staple food is very low in protein content, such as cassava, yams and plantains, kwashiorkor is known to be prevalent.

A shortage of vitamin A is one of the causes of blindness in Third World countries

It is thus obvious that the nutritional quality of foods which one eats controls the optimum physical and mental functioning of the body. Man has observed this from the beginning of time, and certain diets have evolved as a result of his observations. The analysis and planning of diets were not possible until food and nutritional sciences became established to a degree and produced the basic information that made these activities possible. From the knowledge acquired through the development of food and nutritional sciences, conclusions emerged that resulted in the classification of foods into nutritional groups representatives of which are considered to be necessary in all diets to ensure the intake of a recommended minimum of the nutrients. As food science developed, evidence of the links between diets and certain disease symptoms became clearer, and the potential of specific diets in corrective and preventive medicine became recognised. This was the case in the Philippines where polished rice was the staple cereal. The government was faced with a serious health problem from beri-beri. Knowledge that this was due to a deficiency of the vitamin, thiamine, was only a part of what was needed to solve the problem. In order to ameliorate the deficiency and provide the people who lacked it with the thiamine they needed, it was also necessary to possess an understanding of the technology of rice milling, then means could be found of applying the thiamine to a proportion of the rice grains at the polishing stage of their processing. These enriched grains were then available for distribution and could be mixed in the appropriate proportion with the bulk of rice used by the people in the beri-beri-affected areas.

The long term malnutrition problems of the poor nations will, therefore, not be solved by food aid or food trade with the affluent countries, but rather will depend upon dramatic improvements in their indigenous food production capacity and, just as importantly, improvement in the income opportunities of the poor.

The present high and ubiquitous prevalence of protein-calorie-malnutrition in the children of developing countries can thus be traced to a complex interaction of:

- low wages and income, reflecting national poverty
- low per capita productivity in both animal and plant foods both of which could be substantially raised
- poor processing, distribution and marketing systems that result in excessive losses of foods produced
- a lack of knowledge of food values.

It became quite clear at the emergency meeting of the World Food Congress of November 1974 in Rome, that the dominant and most difficult problem to be solved was that of poverty and social or economic deprivation, to which aid of the past has been only indirectly related.

In the long term, these developments involve economic growth in the poor countries. In the short term, there is an urgent need to produce low-cost weaning foods of nutritional adequacy, based upon indigenous raw materials. These foods must be suited to the local eating habits. Through the use of adaptable low-cost, low energy intermediate technology to process foods, the substantial losses of grains, legumes, fruits and vegetables to wastage by insects and rodents would be avoided. It is in both of these areas that an application of the principles of food science and technology can make significant contributions to the needs of developing countries. Although the principles of food science and technology are the same in developing or developed countries, the applications differ depending upon the economic

Table 1.1 World income by economic class, regions and selected countries

Item	Total income 1980	Income distribution	Per capita income	Per capita income growth index
	Billion USA dollars	Percent	USA dollars	1970 = 100
World	4987	100.0	1090	136
Economic class I	3418	68.5	4245	150
North America	1607	32.2	6333	135
Canada	122	2.4	4892	140
United States	1485	29.8	6490	135
Western Europe	1176	23.6	3066	148
EEC	759	15.2	3736	152
United Kingdom	158	3.2	2652	130
Oceania	76	1.5	4055	143
Other developed	559	11.2	3747	218
Japan	520	10.4	4471	231
Economic class II	651	13.1	282	129
Africa	62	1.2	166	119
Latin America	262	5.4	696	128
Near East	105	2.1	470	137
Asia and Far East	220	4.4	166	128
Other developing	2	–	400	134
Economic class III	918	18.4	627	143
Asia centrally planned economies	122	2.4	113	116
USSR and Eastern Europe	796	16.0	2071	159

Income measured by gross domestic product at 1970 constant market prices.

Source: Food and Agriculture Organisation, 1971. *Agricultural Commodity Projections, 1970–1980*, FAO, Rome. Vol. ii, Tables 5 and 6, pp. 14–19.

Table 1.2 Percapita demand for food

Item	HIGH INCOME COUNTRIES Economic class I		USSR and European centrally planned economies		LOW INCOME COUNTRIES Economic class II		Asian centrally planned economies	
	Per capita demand	**Growth index**	**Per capita demand**	**Growth index**	**Per capita demand**	**Growth index**	**Per capita demand**	**Growth index**
	kg per year	1970 = 100	kg per year	1970 = 100	kg per year	1970 = 100	kg per year	1970 = 100
By commodity groups:								
Cereals	85.3	92.9	130.0	91.0	137.3	102.7	148.0	104.3
Starchy roots	65.3	94.6	89.3	79.3	64.2	100.0	91.7	101.8
Sugar	43.6	107.4	43.6	109.1	22.6	112.0	4.8	117.2
Pulses, nuts and oilseeds	7.9	101.7	6.8	107.1	19.1	105.1	15.0	104.4
Vegetables	118.1	109.6	93.0	116.7	43.3	109.0	60.1	107.3
Fruit	103.1	116.0	42.7	133.2	41.0	112.7	7.8	114.2
Meat	85.8	115.5	60.8	119.9	13.6	113.1	20.7	119.5
Eggs	14.9	105.8	10.5	121.3	1.8	119.2	3.8	118.9
Fish	26.5	113.1	24.0	124.1	8.7	118.6	9.5	116.7
Milk and milk products	115.9	99.0	151.0	108.9	31.2	114.7	3.0	116.9
Fats and oils	20.7	103.5	16.9	117.8	6.2	113.7	3.3	121.7
By nutritional terms:								
Energy (kcal)	3,111.0	102.4	3,227.0	101.4	2,307.0	105.2	2,195.0	106.1
Total protein (g)	92.8	103.7	95.1	102.5	59.5	105.5	62.4	106.3
Plant protein (g)	35.3	95.9	48.1	92.5	46.5	103.3	51.6	104.2
Animal protein (g)	57.5	109.1	47.0	115.1	13.0	114.1	10.8	117.5
Fats (gm)	129.1	106.2	101.6	115.3	40.0	110.7	36.1	114.7

Source: Food and Agriculture Organisation. 1971. *Agricultural Commodity Projections 1970–1980*. FAO, Rome, Vol. i. pp. 55 and 59.

status of the country.

This book is written in response to the need for a textbook on food science and technology in which the emphasis is on the needs of people in developing countries. The main objectives are to provide a comprehensive introduction to the theory and practice of food science and technology which can be used as a basic text for a course for students and teachers in Universities, Polytechnics, Colleges of Technology and Education and other institutions of higher learning in the Tropics. The book should however be of equal value to Food Industries, Governments and Research Institutes involved in food production, utilisation, diversification and preservation; and finally to informed consumers and those – nutritionists, dietitians, home economists, etc. – who advise or educate them about food.

The contents of this book are divided into two main sections. The first section deals with the fundamental basis of food science and technology covering the following subjects: the chemistry of basic food components, food microbiology and preservation, food process engineering, quality control and organoleptic attributes of food, nutritional and physiological aspects of foods, browning reactions and the instruments for food regulation and standards in the tropics. The second section is devoted to the processing of specific tropical food commodities.

We have not attempted to provide references to the original sources of the information given in this book; such references would greatly increase the length and cost of the book and would, we feel, be used by relatively few readers. A short list of papers and books recommended for further reading is given at the end of most chapters. We have tried to make these lists selective rather than comprehensive. In a book of this type which tends to summarise such a large and expanding field of knowledge and which for the first time, presents food science and technology in an adaptable and utilisable form for people in developing countries, it is perhaps inevitable that errors and ambiguities will occur. We should be grateful if any such inaccuracies for which we are alone responsible could be brought to our knowledge.

Bibliography

LDC's dossier *Development Forum* Vol. IX No. 6. United Nations University, pp. 4–6, 1981.

World Food Survey, FAO Statistics Series Nos. 10 and 11, FAO, Rome, 1977.

Agricultural Commodity-Projections for 1970–1980, 2 vols. FAO, Rome, 1971.

Third World Food Survey, Freedom from Hunger Campaign, Basic Study No. 11, FAO, Rome, 1963.

SECTION 1

Scientific basis of food science and technology