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Food Science and Nutrition: The Gulf Between Rich and Poor

Joseph H. Hulse

Summary. The people of economically developed countries benefit greatly from modern food science. They are protected from food contamination, have access to a great variety of food, and need spend little time preparing it. The poor in developing countries enjoy few of the benefits of food science. Their diets are often nutritionally deficient and they spend many hours each day processing their food and searching for wood with which to cook it. In most tropical countries food losses between harvest or slaughter and eventual consumption are inestimable. Efforts to improve postharvest food systems in developing countries require the attention and ingenuity of many scientific disciplines and the support of all development agencies.

The Brandt Commission (*1*) describes the gap which separates rich and poor nations as being so wide that at the extremes people seem to live in different worlds. The contrast in life-styles is particularly evident in the relative quality of their diets, to which food science has contributed so much for the richer and so little for the poorer.

Food Science in Developed Countries

Historically, food science has been devoted to an understanding of the biochemical and biophysical nature and composition of foods, the changes that foods undergo after harvesting, and during such traditional technological transformations as fermentation, milling, drying, frying, baking, boiling, and other forms of cooking. For people in developed countries, food science combines the skills and knowledge of chemists, physicists, microbiologists, nutritional biochemists, engineers, and many other professions to provide the most varied range of wholesome diets in the history of mankind. From large grocery stores people can choose several thousand different food items at all times of the year, and many spend less than a quarter of their disposable income on feeding themselves. As much as, if not more, than any other branch of learning, food science has made it possible for both parents in a household to pursue their careers without detriment to the adequacy or variety of their family's diet.

The raw materials of the food scientist are more highly and uncontrollably variable than most of those used by inorganic chemists. The properties and composition of the seeds and fruits of cultivated plants are influenced by genetic background, the environmental conditions of soil and climate under which they are grown, and the methods by which they are harvested, stored, and processed. At all stages after harvesting, both during and after processing, changes take place involving so many diverse and complex chemical reactions that it is impossible to follow any one in isolation from the rest. Consequently, the extensive body of knowledge acquired has resulted from both biochemical and biophysical measurement and from empirical observation.

Many food plants, including those widely accepted, contain substances unsuitable for ingestion. Some, for example, contain mycotoxins resulting from infection of grains in the natural environment; others synthesize toxic substances that protect them. Primitive people, probably by trial and error, found simple ways to eliminate, or reduce to relatively safe levels, naturally occurring toxins and nutritional inhibitors present in their staple food sources. Typical are the

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Table 1. Population per arable hectare in selected countries, 1975 (12). Arable hectares includes land used for both annual and permanent crops.

Country	1975 Arable hectares (millions)	1975 Population (millions)	1975 Persons per arable hectare	Annual rate of natural increase, 1965 to 1975 (%)
Mexico	28	60	2	3.5
South Korea	2.4	34	14	2.0
India	167	608	4	2.0
China	129	823	6	1.7
Kenya	1.8	13	7	3.3
Tanzania	6.1	15	2	2.8
Egypt	2.9	37	13	2.3
All less developed countries	670	1900	3	2.5

Table 2. Projected population per arable hectare in selected countries, 1985 and 2000 (12).

Country	1985		2000	
	Population (millions)	Persons per arable hectare	Population (millions)	Persons per arable hectare
Mexico	85	3	136	5
South Korea	41	17	54	22
India	741	5	983	6
China	974	7.5	1241	10
Kenya	18	10	28	15
Tanzania	20	3.5	30	5
Egypt	46	16	63	22
All less developed countries	2400	3.5	3343	5

methods of water elution, fermentation, and drying used by Amerindians to remove cyanogenic glucosides from cassava roots and the saponins present in chenopods, other seeds, and some potato genotypes. The decreased protein digestibility caused by the polyphenolic tannins present in the outer layers of some sorghum grains is probably offset by traditional methods of soaking in water or by alkali treatment with wood ash before grinding and cooking (2). In scientifically controlled food systems, the food chemist and plant breeder cooperate in the elimination of antinutrients by genetic selection or processing.

The adulteration of wine, beer, bread, and spices occurred from the time they first became articles of commerce. Food adulteration was not a matter of widespread concern, however, until the time of the Industrial Revolution when large populations moved from subsistence agriculture to urban industry and came to rely upon foods produced and processed by others. Many of the adulterations of the Industrial Revolution, including the addition of alum to bread and of copper and other metallic salts to foods to improve their color, probably arose as much from a desire to improve the food's appearance as from intent to deceive the consumer.

Because of the pioneering work of Hassall in Britain, which led in 1860 to the world's first Food and Drugs Act, the reports by Pasteur to the Board of Hygiene and Sanitation in Paris, and subsequently to the professional competence and vigilance of many food protection agencies, hazardous, deliberate adulteration is not common in most developed food economies. Government agencies and food industries invest heavily in inspection and use advanced analytical techniques to ensure that all foods marketed are safe and wholesome.

Malnutrition in Developing Countries

While food science has made an immense contribution to the physiological, economic, and social well-being of people living in the world's wealthier countries, such is not the case among the rural poor in Africa, Asia, Latin America, and the Middle East. In these countries the underprivileged struggle to find food sufficient to survive, and must often walk many miles in search of wood with which to cook it.

Though for the poorest, malnutrition is a condition close to starvation, malnutrition in its broadest sense results from a diet inadequate to maintain satisfactory physical and mental development. Malnutrition impairs the capacity for work output and lowers resistance to infection. Infection, in turn, increases the food nutrient demand to repair the damage wrought by disease. Malnutrition and chronic infection impair learning ability which further reduces the capacity for effective work. Consequently, malnutrition begins a vicious circle broken only by provision of an adequate diet.

In countries of the African Sahel, where 70 to 80 percent of the energy is provided by cereals, seasonal variations in available food energy occur every year (3). During the months immediately before the harvest energy intake generally averages 25 to 30 percent less than the intake immediately after harvest. In the drought years of the early 1970's, energy intake deficiencies of close to 50 percent were recorded (3). The survey data available (3) illustrate the wide variability in available food among years, among seasons, among communities, among age groups, and between settled and nomadic life-styles. Even when, among the rural poor, calorie intake is sufficient, the diet of many young children is nutritionally unsatisfactory. This is largely because the protein content and amino acid composition of the locally grown cereals, whatever the quantity ingested, are inadequate to satisfy a child's needs.

The chemist can analyze the relative composition and levels of concentration of most known nutrients, but chemistry alone cannot determine nutritional adequacy. The adverse effects of grossly excessive or inadequate nutrient intakes are often demonstrable, but what constitutes an ideal diet for any condition of man, woman, or child is far from certain.

In domestic and farm animals nutritional balance can be determined according to such desirable characters as rate of weight gain and carcass composition. Nutritional requirements for human health cannot be so easily prescribed since they involve such complex criteria as resistance to infection, healthy longevity, physical fitness, and intellectual capacity, not one of which is very easily quantified.

Nutritional studies with human subjects are expensive and time-consuming; humanitarian and ethical considerations restrict the range of variables that may be studied, the techniques of assessment that can be used, and the period of time over which any experiment may be continued. Consequently, recommended daily allowances of all dietary standards are the results of professional judgments based on the best available evidence. Recommended daily allowances of known essential nutrients have changed over the years and are still not uniform among all countries.

In the mid-1930's the League of Nations Committee on Nutrition wrote in its report (*4*): "The movement towards better nutrition in the past has been largely the result of the unconscious and instinctive groping of men for a better and more abundant life. What is now required is the conscious direction towards better nutrition. Such direction constitutes policy. Nutrition policy . . . must be directed towards two mutually dependent aims: first, consumption, bringing essential foods within reach of all sections of the [world] community; second, supply." The report then listed several courses of action necessary to ensure an adequate consumption and supply, including the recognition of nutritional policy as of primary national importance; better education on human nutrition; and a more equitable distribution of income since it is "the poorest people who are the most nutritionally deprived."

Forty years later, the following statement appeared in the *World Food and Nutrition Study* by the National Research Council of the United States (*5*): "An important cause of malnutrition is the absence of policies and programs to foster the best use of available food supplies. . . . In poor and rich countries alike, governments continually make decisions that affect nutritional status with little or no knowledge of the nutritional consequences. Success in alleviating hunger and malnutrition will depend upon increasing the supply of the right kind of food, reducing poverty, improving the stability of food supplies, and decreasing the rate of population growth." Thus a committee composed of eminent scientists repeated the recommendation which an equally distinguished committee prescribed 40 years earlier.

It is impossible to determine the extent of malnutrition throughout the developing world, since statistical assessments of gross food production, combined with doubtfully reliable estimates of population, provide at best crude averages of available food per capita. Little that is precise and reliable is known of the nutritional losses between harvest and consumption, or of the many political, social, and economic forces that constrain production, distribution, and consumption of essential foods. Relatively few countries appear to have created mechanisms by which to plan and monitor the production and fair distribution of essential nutrients.

Two adverse influences appear persistent and pervasive. First is an apparent reluctance to study and comprehend post-harvest systems as they exist and to diagnose inadequacies before prescribing palliatives. The second, related to the first, results from an unwarranted optimism in the transferability of technology. To those who advocate the transfer of appropriate technology one might ask "appropriate to whom—to those who seek to transfer or those who are to receive?"

Methods to Increase Production

Broadly speaking, the food available to any population can be increased by (i) higher levels of productivity per unit of land, (ii) the expansion of land under cultivation, and (iii) greater efficiency in food conservation and distribution.

Higher productivity per unit of land. Research at the international agricultural research centers (*6*) demonstrates how high-yielding cultivars of wheat and rice can increase cereal grain production in developing countries. The benefits to be derived from higher yielding food crop types and the improved agronomic systems by which they are sustained are far from being exhausted. It now requires that greater attention be given to the quality of edible grains of high-yielding cereals and to the influence on nutritional adequacy of changing agricultural patterns.

The nutritional composition of all cereal proteins falls short of the standard reference pattern recommended by the FAO/WHO Expert Committee in 1975, since cereal proteins, in varying degrees, are deficient in the essential amino acid lysine.

The protein in food legumes is nutritionally complementary to that of cereal grains. A combination of roughly two parts by weight of cereal with one part by weight of dried food legume (pulse) provides a combined amino acid composition close to what is nutritionally desirable. Probably because of their low yields relative to wheat and rice, the area given to food legume cultivation in Asia has fallen significantly over the last two decades and, rather than the nutritionally desirable ratio of two metric tons of cereal for every ton of legume, the Asian legume harvest approximates only one-tenth that of cereal production (*7*).

In India, where rice and wheat production have increased dramatically over the past two decades, the harvest of food legumes and oilseeds appears to be declining. The 1979–1980 Indian legume harvest was 4 million tonnes below that of 1978–1979 and 2 million tonnes lower than the average for any year since 1951. In many developing countries, the production of oilseeds, which provide edible vegetable oils and protein nutritionally complementary to cereals, is grossly inadequate to meet present needs. Some of the poorest countries expend millions of dollars annually to import oilseeds and vegetable oils. In contrast, some of the more affluent developed countries seek to substitute vegetable oils for mineral oils as engine lubricants and fuels.

Expansion of land under cultivation. The area of land under cultivation may well prove to be the most critical factor that determines the number of people who can be fed in the years ahead. During 1975 an average of approximately three people in developing countries were fed from each hectare of cropland. By extrapolation of an estimated population increase of 3 percent per year, during 1985 each hectare cultivated in 1975 will need to support four people and, by the end of the century, close to six people. These crude averages do not reveal dramatic differences among different developing countries.

Tables 1 and 2 illustrate the justification for cautious optimism in some instances, and near despair in others. In 1975, 60 million Mexicans were supported by 28 million hectares of arable land, equivalent to about two persons per hectare. In the same year, 37 million Egyptians depended on 3 million arable hectares, equivalent to 13 people per hectare. It is estimated that by 1985 each arable hectare will need to support 3 Mexicans or 16 Egyptians and that by the year 2000 it will increase to 5 Mexicans and 22 Egyptians per arable hectare. The International Development Research Centre is cooperating with several universities and government agencies in an attempt to reclaim areas of the Egyptian desert for future agricultural production. Even with irrigation from the Aswan Dam it is difficult to reclaim cultivable land at a rate equivalent to the loss caused by the spread of Cairo.

The depredation of arable land by urban sprawl is by no means confined to Egypt and other developing countries. The production of food surpluses to meet national requirements can be expected to decline in those countries of North America and Europe whose governments persist in assigning higher priority to industrial growth than to agricultural production; who permit large areas of their best arable land to be devastated by urban growth and by the proliferation of highways and industrial complexes. The world over, conservation of arable land, of inland coastal waters and natural forests, seems to take second place to urban and industrial development.

In Canada, for example, between 1971 and 1976 irretrievable losses of higher quality agricultural land to urbanization amounted to more than 38,000 hectares, most in the fertile and climatically favored areas of the Montreal triangle, southern Ontario, and the Fraser River Valley of British Columbia. In the United States, the Department of Agriculture calculated that 2.5 million hectares of cropland were converted to urban and related uses between 1967 and 1975, and from Europe similarly dismal statistics of urban sprawl across prime class agricultural land are reported.

Greater efficiency in food conservation and distribution. The Brandt Commission (*1*) reports that "eight hundred millions are estimated to be destitute in the Third World today." From statistics cited by FAO (*8*) and the International Food Policy Research Institute (*9*), it appears that between 1976 and 1980 world cereal production increased by about 5 percent whereas world population expanded by 9.5 percent. Over the same 4-year period, cereal imports into all developing countries increased by 66 percent and in the lowest income countries the proportion of cereal imports provided under food aid programs decreased by more than 30 percent. During the same period cereal stocks, expressed as a proportion of total world cereal consumption, decreased by 22 percent; the estimated world cereal stock for 1981 was roughly the same as the world stock held in 1974, the year when the World Food Congress was convened to emphasize an impending world food crisis.

For the next decade and beyond, prospects for a minimally adequate diet among the world's poorest people appear grim indeed. The lowest income food-deficient nations, which represent almost two-thirds of the total population of developing countries, showed a food deficit equivalent to about 12 million tonnes of cereals in 1975. In these same low-income countries it is forecast that by 1990 the food grain deficit may be six to seven times that of 1975.

Scientific principles are universally transferable; many technologies are not. Technologies based upon biological principles, whether they relate to the cultivation of edible plants or to the transformation, preservation, and distribution of plant and animal products, are intensely influenced by their surrounding physical, social, and economic environments. Consequently, it is difficult, and frequently impossible, to transfer post-production (post-harvest) technologies and food processing systems from countries with temperate climates and access to advanced technological control to less privileged communities of the semiarid and humid tropics. Post-production systems need to be studied comprehensively and in their entirety before change is proposed (*10, 11*). New or improved post-harvest technologies, based upon sound scientific principles, are best developed where they are to be used, in close cooperation with those who are to use and benefit from them. What is good for North Americans is not necessarily good for North, West, East, or Southern Africans, particularly those living in poor rural communities.

To provide what is appropriate to need requires a change in political attitude among many who dictate the policies of bilateral assistance and those responsible for the training of future scientists in developing countries. The need for a comprehensive understanding of scientific principles is unquestionable. But in addition, food scientists and administrators need a broader comprehension of system methodologies in order that each technological change can be effectively integrated into the system in which it is to function (*11*).

International Cooperation

Though opportunities for the simple transfer of food technologies between rich and poor nations may be limited, the many opportunities for cooperation among scientists of all nations remain largely unrealized. More encouragement for sympathetic, sensitive, cooperative research between scientists in developed and less developed countries is essential if the future adequacy of the world's food supply is to be ensured.

Relevant to this whole subject is the forthcoming CHEMRAWN II meeting, "The International Conference on Chemistry and World Food Supplies—The New Frontiers," scheduled for Manila, Philippines, 6 to 10 December 1982. This gathering will bring together leaders from developing and developed countries for the purpose of identifying areas of research and development having the potential to significantly improve the production, processing, and storage of food in Third World countries. Recommendations for future action will be developed by the conference organizers, taking into consideration the social, economic, and environmental factors as well as the technical components involved.

In another approach to international cooperation, the International Council of Scientific Unions (ICSU) has created a Commission for the Application of Science to Agriculture, Forestry and Aquaculture (CASAFA) to stimulate cooperation in relevant research among the national academies and international scientific unions which constitute ICSU's membership. Several countries are in the process of establishing national CASAFA committees and it is hoped eventually that most countries will do so. The participation of many disciplines is needed including several not commonly associated with food and agriculture.

In addition, the government of Canada recently created a Cooperative Program, administered by the International Development Research Centre, the purpose of which is to employ Canadian scientific resources for the benefit of less developed nations.

Though a nutritionally adequate diet for all mankind over the next two decades is far from being assured, universal food sufficiency can be realized if politicians, policy-makers, and the world's community of scientists accept the dictum of one of FAO's most enlightened directors, B. R. Sen: "One man's hunger is every man's hunger; one man's need is every man's need."

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