PROCEEDINGS OF A 1977 WORKSHOP HELD ON THE

INTERFACES BETWEEN AGRICULTURE, NUTRITION, AND FOOD SCIENCE

THE UNITED NATIONS UNIVERSITY AND THE INTERNATIONAL RICE RESEARCH INSTITUTE

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Foreword

THIS PUBLICATION IS BASED on the proceedings of the workshop *Interfaces between Agriculture, Nutrition, and Food Science,* jointly sponsored by the United Nations University (UNU), and the International Rice Research Institute (IRRI), and held at IRRI, Los Baños, Philippines, 28 February to 3 March 1977.

One of the priorities in the World Hunger Programme of the UNU is greater understanding of the interrelations and interactions among those concerned with agricultural production, food science, and nutrition. A primary concern is making knowledge of nutritional needs and of applicable food science and technology available to breeders, planners, economists, and others concerned with agricultural production. Conversely, information on primary food production possibilities and limitations has to be transferred to experts in the fields of human nutrition, food technology, agricultural economics, and development planning. Some areas where information is required are human nutritional needs, technology for reducing quantitative and qualitative preharvest and postharvest food losses, role of agricultural production in meeting nutritional goals in terms of quantity and quality, nutritional and processing considerations in agricultural research, availability of nutrients from food and factors affecting this, and selection of goals for upgrading the nutritional value of plant and animal food sources.

Unfortunately, there has been all too little interchange among scientists and program planners and implementers concerned with food production, food science, and nutrition. As a consequence, ignorance on the part of one group as to the problems, activities, and accomplishments of the others is common. This lack of information and communication often leads to needless conflicts among scientists and to confusion in the minds of decision makers at national and international levels.

The UNU-IRRI Workshop had as its objective the promotion of better understanding of the interfaces between agriculture, food, and nutrition among experts concerned with agricultural research and policy, human nutrition, food science, and food technology in the countries of the Southeast Asian region. A multidisciplinary group of over 30 senior scientists and research workers from the different countries of the region attended and contributed to the success of the Workshop. They presented scientific papers of mutual interest and their discussions helped open up avenues of future cooperation and collaboration. The UNU and the IRRI acknowledge with gratitude the partial financial support provided by the Rockefeller Foundation for organizing and implementing this Workshop.

Publication of the Workshop proceedings is part of the effort of the UNU and the IRRI to disseminate, as widely as possible, technical information that can lead to progressive improvements in the national food supplies and in the nutritional and health status of the populations of the developing countries.

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Introductory remarks

NEVIN S. SCRIMSHAW

INCREASINGLY SHARP AND DANGEROUS differences in nutrition and food supply divide the privileged and underprivileged populations, the developed and technically underdeveloped countries. Malnutrition stunts the growth and development of most children, and malnutrition and infectious diseases interact to give mortality rates for preschool children that are from 20 to 50 times greater in the developing countries of Asia than in the United States and Europe. Because their population growth rates are so much higher, many of these developing countries are unable to produce enough food to keep up with this increase, much less to catch up with the food deficit and undernutrition already suffered by their populations.

But population increase accounts for only part of the increased world demand for grain; the other major factor is rising demand associated with greater affluence. Figure 1 shows that the combined result of population growth and increased per caput demand for food creates an alarming prospect (Wortman 1976). The shaded area shows the deficit in food production relative to food demand in the developing countries up to 1975-76 and the estimated increase in this deficit for high and low projections of income growth to 1986.

Protein-calorie or protein-energy malnutrition (PCM or PEM) in the lower socioeconomic groups of Asian countries is so widespread that it affects nearly all young children, as revealed by some degree of growth retardation in most of them. In many cases this degree of malnutrition is sufficient to lower resistance to infection. Of far greater concern is the fact that malnutrition and infection combine synergistically in producing the high death rates among these children in the early years of their lives. This, in turn, makes the acceptance of family planning more difficult in regions where the survival of children is important for the security of parents once the latter can no longer work. Moreover, the frequency of infec-

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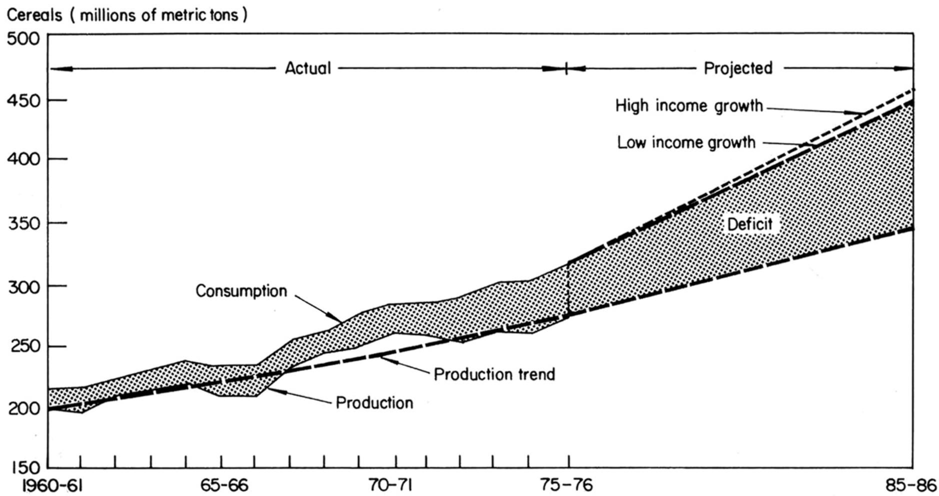

1. Future food deficit in the developing countries is foreseen by the International Food Policy Research Institute. Actual data are given, for cereal production and consumption in the market-economy developing nations that have food deficits, up to 1975-76 (the crop year just ended). The trend of production since 1960-61 was calculated and the trend line projected to 1985-86. Future demand was projected from current human consumption on the basis of population growth and alternative assumption about growth of per capita income (modified by "income elasticity" data reflecting the extent to which incremental income would be committed to cereal consumption); to this human demand, grain consumed as animal feed is added for countries rich enough to convert much grain into meat. Three demand projections are shown. One assumes no improvement in per capita consumption over the 1969-71 level (solid line), one assumes low growth of income, and one assumes high income growth (dotted line). The curves measure economic demand, not actual need.

tion in malnourished individuals further worsens their nutritional state, both because food intake and nutrient absorption are reduced, and because metabolic losses of nitrogen, some vitamins, and key minerals are increased.

There is now a clearly established association between retardation in weight and height for age caused by malnutrition in the preschool years, and poor performance on tests of intelligence, learning, and adaptive behavior. This occurs probably because malnourished children are apathetic and do not receive sufficient stimulus from interaction with adults or with their environment. Without improvements in both early nutrition and environmental stimulation, the learning and behavioral deficits become lasting.

Thus, the frequent chronic malnutrition among young children in the developing countries is continuously crippling the future generations upon whom any country must ultimately depend. Malnutrition among pregnant women is a major cause of low birth weights and associated high infant and preschool child morbidity and mortality, and these are exacerbated when mothers are undernourished during lactation. Malnutrition also limits the contribution of these mothers to their important economic and social responsibilities to their families and communities.

Undernourished adults are unable to work as hard or as long as well-nourished ones; their increased absenteeism caused by frequent illness further reduces productivity. The major reasons for such illness include inadequate dietary energy intake and chronic iron deficiency. When food calories are limited, the individual must adapt by conserving energy expenditure or ultimately perish, and individuals who are anemic have lower working capacity. Small supplements of whichever is limiting, calories or iron, have resulted in striking increases in productivity in recent field studies.

Most malnutrition and hunger occur not because of lack of natural resources, but because of the lack of political will and trained manpower to take the necessary economic and social measures, and to apply available technical knowledge. For this reason, we see some developing countries making rapid progress in improving the nutrition, health, and well-being of their people, while others simply accumulate more people whose nutrition and health remain deplorable.

Supplementing the efforts of the countries themselves is the system of International Agricultural Institutes, of which the host institution for this meeting, the International Rice Research Institute (IRRI), is the highly successful prototype. Others that are part of the Consultative Group on International Agricultural Research (CGIAR) include the International Maize and Wheat Improvement Center (CIMMYT), the International Center for Tropical Agriculture (CIAT), the International Institute of Tropical Agriculture (IITA), the International Potato Center (CIP), the International Crops Research Institute for the Semi-Arid Tropics (ICRISAT), the International Laboratory for Research on Animal Diseases (ILRAD), the International Livestock Center for Africa (ILCA), the West Africa Rice Development Association (WARDA), the International Board of Plant Genetic Resources (IBPGR), and the International Center for Agricultural Research in Dry Areas (ICARDA).

The agencies of the United Nations System most concerned with assisting countries to solve their food and nutrition problems are the World Health Organization (WHO), the Food and Agriculture Organization (FAO), the United Nations International Children's Emergency Fund (UNICEF), and the World Bank Group. In addition, the newly established United Nations University (UNU), with headquarters in Tokyo, has world hunger as one of its three main concerns. The UNU World Hunger Programme priorities are better understanding of human nutritional requirements under the conditions prevailing in developing countries and their fulfillment by local diets; postharvest conservation of food through protection from rodents, insects, and spoilage; and the development of sound food and nutrition policies and programs as part of national development planning. It is also supporting regional workshops, such as this one, to increase understanding of the many interfaces between agriculture and food and nutrition.

This Workshop, jointly sponsored by the UNU, the Rockefeller Foundation, and IRRI, has as its objective the initiation of a dialogue among individuals concerned with agricultural research and policy, human nutrition, and food science and technology in the Asian region. It has been designed to explore the nutritional considerations that are inherent in food production, processing, and distribution. It emphasizes the multiple interfaces among programs in the agricultural, health, education, and economic sectors, and their significance for national development policy and planning. The series of relevant questions listed in Appendix I were not answered in any systematic manner, but to the extent that limitations of time and expertise permitted, they were discussed realistically.

APPENDIX I. POLICY QUESTIONS CONSIDERED BY THE WORKSHOP

Food Production and Nutrition

1. To what extent are hunger and malnutrition problems of food production?
2. To what extent does improved cereal production
   a. help to prevent malnutrition?
   b. contribute to malnutrition?
3. What is the relation of legume production to malnutrition?
4. What are the financial and nutritional risks for the small farmer if he adopts new varieties and costly inputs?
5. What is the feasibility of crop diversification to achieve nutritional goals?

Postharvest Technology and Nutrition

1. What is the magnitude of preventable postharvest food losses in Asian countries?
2. What proportion of these losses is caused by
   a. rodents?
   b. insects?
   c. molds?
   d. simple spoilage?
   What is the nutritional significance of these postharvest food losses for
   a. the family?
   b. the community?
   c. the nation?
4. What specific measures can be applied to reduce these losses
   a. in the home?
   b. in the community?
   c. on a national scale?
5. What do food processing and the food industry contribute to more efficient use of food resources?

Malnutrition and Agriculture

1. What are the relative nutritional values and problems associated with various staple foods such as rice, maize, and sorghum?
2. What is the nutritional role of legumes in human diets?
3. Is animal protein essential to human diets?
4. For plant breeders, which nutritional goals are rational and potentially significant, and which are unlikely to be useful for the following:
   a. rice
   b. maize, sorghum
   c. yam, sweet potato
   d. legumes

Socioeconomic interfaces of Agriculture and Nutrition

1. What nutritional significance does increased income have on changing food patterns?
2. What is the relationship, or lack of it, between nutritional need and effective demand for foods?
3. How are changes in food prices and/or family income reflected in the amount and kinds of foods purchased, and in the nutritional value of the diet?
4. What is the basis for widespread protein-calorie malnutrition among infants and preschool children in Asia? How can it be overcome?
5. What is the relationship between the nutritional status of adults and agricultural productivity?
6. Are indigenous food beliefs and practices consistent with good nutrition? How can they be improved?
7. Are there specific nutrition intervention programs that will alleviate malnutrition without changes in agricultural production?

Food and Nutrition Policy

1. For food-short countries, what is the proper balance between
   a. food crops and cash crops?
   b. cereals and legumes?
   c. plants and animals?
2. For feeding people,
   a. what are the considerations in a balanced agricultural research program?
   b. what should be the relative incentives for raising various crops?
3. What effects do price controls have on
   a. nutrition of low-income groups?
   b. food availability?
4. What effects do food reserves have on
   a. food prices?
   b. food production?
5. What agricultural extension or systems approach will most benefit the diet of
   a. the small farmer?
   b. the landless agricultural laborer?

REFERENCE CITED

WORTMAN, S. 1976. Food and agriculture. Pages 3-11 *in* Food and Agriculture, a Scientific American book. Reprinted from the September 1976 issue of Scientific American, W. H. Freeman Company, San Francisco.

Malnutrition, food patterns, and nutritional requirements in Southeast Asia

Y. H. CHONG

SOUTHEAST ASIA, or eastern South Asia, includes the following nations: Brunei, Burma, Indonesia, Khmer, Laos, Malaysia, the Philippines, Singapore, Thailand, Timor, and Vietnam. The region is characterized by people of diverse racial, ethnic, cultural, and religious origins, representing indigenous populations as well as immigrants (Whyte 1974). Four world religions — Islam, Hinduism, Buddhism, and Christianity — are practiced in the region. It would be pretentious to attempt to cover the subject of malnutrition, food patterns, and food requirements over so wide an area; this discussion is, therefore, confined to Indonesia, Malaysia, the Philippines, and Thailand.

DEMOGRAPHIC BACKGROUND

These four nations are inhabited by about 220 million people who are predominantly rural, with a mean of about 68% of the population engaged principally in agriculture (Table 1). This is in striking contrast to, for example, the 4% agricultural population of the United States.

The overall population density of the four nations is considerably higher than that of the United States, but much lower than that of Japan. The density varies greatly within countries in the region. For example, 63% of the total population of Indonesia is concentrated in Java-Madura, which comprises only 7% of the total land surface. The population in the region is a young one: 16% are younger than 5 years, and 44% are under 15. Thus, the working population carries a heavy burden of dependency.

The ratio of physicians to population is, or, the whole, low. In Indonesia, the overall ratio is 1 doctor for 18,000 people, but this can vary from 1 for 2,600 around Jakarta to 1 for 200,000 in the Outer Islands (Hapsara 1975).

In Indonesia and Thailand, life expectancy at birth for both males and females is low, and appears to be shorter than that in Malaysia and the

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Table 1. Some key demographic data.

Country	Population[a] (million)	Density (no of persons /km²)	Rural population (%)	Agricultural population (%)	Population (%)	
					Under 5 years	Under 15 years
Indonesia	127.6	86	82	70	16.2	44
Malaysia	11.7	35	71	56.5	15.5	43
Philippines	41.5	138	68	69.5	16.7	43
Thailand	41.0	80	87	76.5	16.4	44
Singapore	2.2	3819	0	8	10.3	35
Japan	109.7	295	28	21	9.0	24
USA	211.9	23	26	4	7.7	26

[a]Midyear estimate, 1974. Sources: UN demographic yearbook 1974; UN statistical yearbook 1974.

Table 2. Some key vital statistics.

Country	Crude birth per thousand	Crude death per thousand	Natural increase per thousand	Infant mortality per thousand	Annual deaths of children 5 years & below[a]
Indonesia	48.3	19.4	28.9	135	51
Malaysia (peninsular)	33.3	6.9	26.4	35.5	26
Philippines	26.1	6.8	19.3	58.7	50
Thailand	42.8	10.4	32.4	27.0	23
Singapore	19.9	5.3	14.6	16.5	Not available
Japan	19.4	6.6	12.8	11.3	Not available
USA	15.0	9.1	5.9	16.5	5

[a]Expressed as a percentage of total deaths. Source. UN demographic yearbook 1974, and recent national statistics.

Philippines. The high infant mortality rate in Indonesia is a major determinant of the shorter life expectancy in this country (Table 2,3). Death rates in the four countries have fallen in recent years, but birth rates have continued to remain high, reflected in the population increase in the Philippines before 1970 (Fig. 1). Mortality rates for infants and toddlers, age groups particularly sensitive to malnutrition and infection, are generally high in the region, particularly in Indonesia (Table 2), where the number of deaths of children under five, expressed as a percentage of total deaths, is highest (Table 2).

NUTRITIONAL PROBLEMS

Protein-energy malnutrition

The major problem in the region is, without doubt, protein-energy malnutrition (PEM), basically the result of varying degrees of deficiency in both calories and protein, often aggravated by infections. PEM is a broad

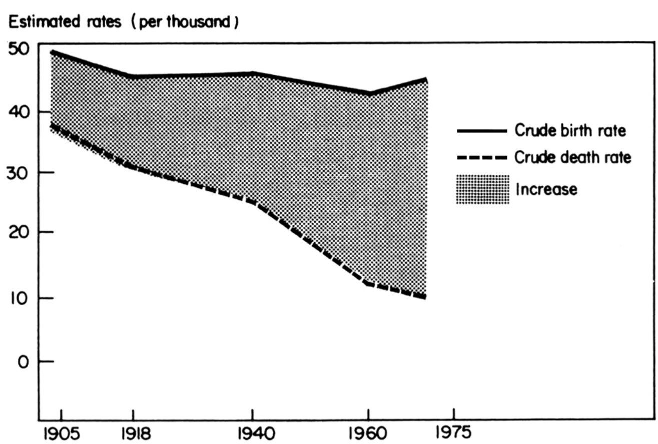
Table 3. Life expectancy at birth, and doctor-population ratio.

Country	Life expectancy at birth (years)		Doctor-population ratio
	Male	Female	
Indonesia[a]	48.5	49.0	1:18,000
Malaysia	63.3	68.0	4.007
Philippines[b]	59.0	65.0	1,000
Thailand	53.6	58.7	7,971
Singapore	65.1	70.0	1:1,200
Japan	70.5	75.9	1: 867
USA	67.4	75.2	1: 621

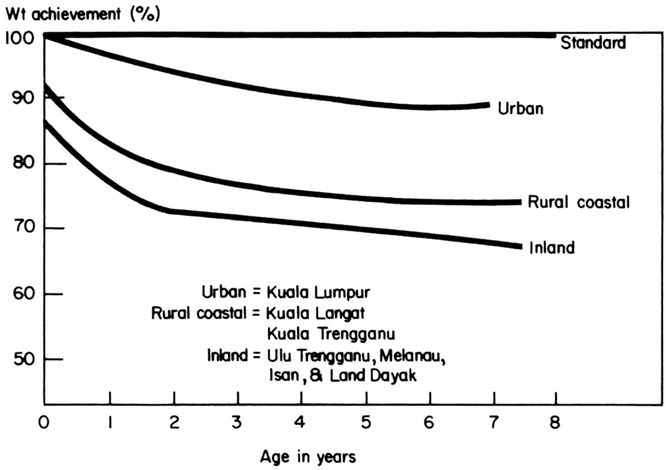
[a] 1964. [b]1974 Source: UN demographic yearbook 1974, and various national statistics

term that describes a syndrome of undernutrition ranging from the often severe and fatal forms of kwashiorkor and nutritional marasmus to the more moderate forms that are manifested usually by retarded physical growth, apathy, and impaired learning capacity.

Generally, the weights of rural children in the region are markedly lower than those of well-nourished North American children, particularly during the immediate postweaning period, and continue to remain low up to school age. The growth retardation seen in Malaysia is most severe in children in the remote inland areas, intermediate in children in coastal villages and in the more prosperous rural areas, and least marked among urban preschool and primary school children (Fig. 2). In Malaysia, toddler mortality rates, which are sensitive indicators of malnutrition, have been shown to correlate inversely with the percentage of the gross national product derived from food crops produced in the various states (Nicol



1. Estimated rates of birth, death, and natural increase in the Philippines, 1903-70. Source: UP Population Institute (1970).



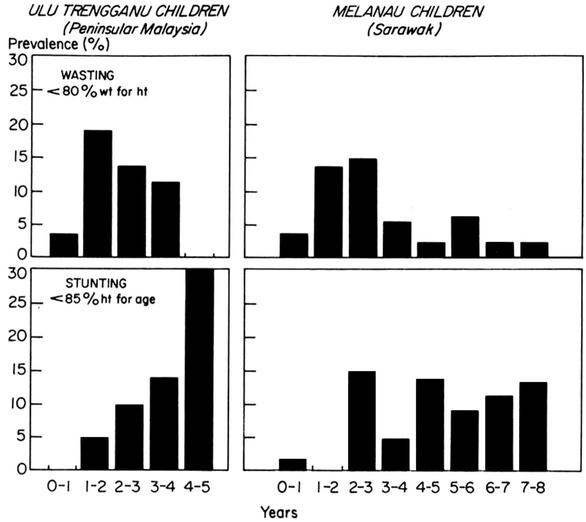
2. Comparative weight achievement of Malaysian children (as % Harvard standard). Source: Chong (1975,1976) and Anderson (1976a, b, c).

1975). These statistics illustrate the well-known association between environmental and socioeconomic factors and malnutrition.

Figure 3 shows the greater prevalence in preschool children of "wasting" during the weaning and immediate postweaning period, compared to "stunting," which appears to increase only after the weaning period. "Wasting" gives a measure of the current status of malnutrition, while "stunting" reflects a past history of chronic malnutrition (Waterlow 1973). The prevalence of severe PEM, by the criterion of weight for age of less than 60% of the Harvard Standard, ranges from 0.2 to 8.8%, while the moderate form of PEM varies between 5 and 38% (Table 4). Bengoa (1974) has reported median prevalence rates of 3.2% for severe PEM and 31.2% for moderate PEM in Asia. Assuming that Bengoa's median prevalence rates also hold true for the region under discussion, it may be estimated, with the aid of the demographic data in Table 1, that at least 1.2 million children 1 to 4 years old may be suffering from severe PEM, and 11.7 million in the same age group from moderate forms of PEM. By this modest estimate, around 13 million children in the region may be said to have some degree of PEM at any one point in time.

Iron deficiency anemia

In Asia, about 10% of the men, 20% of the nonpregnant women, and 40% of pregnant women have iron deficiency anemia, while as many as 92% of the children under 2 years of age may be affected by this nutritional disorder (Bengoa 1974). Iron deficiency anemia is associated with high mor-



3. Prevalence of "wasting" and "stunting" among rural inland children in Malaysia. Source: Chong (1975) and Anderson (1976a).

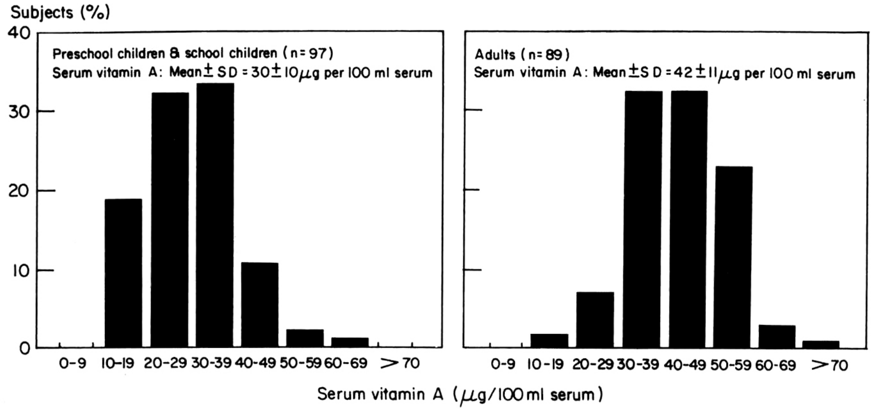
tality and morbidity in young children and pregnant women in many developing countries. It is also known to affect the productivity of agricultural workers, and to decrease an individual's ability to resist infections. Blood loss from hookworm infection and malaria compounds the primary lack of iron in the diets of the region, where deficiency in animal proteins is the rule for most of the population.

In Thailand, 70% of the preschool children in two northeastern rural villages were reported to have hemoglobin levels below 10 g% (mean 9.3 g and 8.9 g%); 10% and 21%, respectively, also had hookworms (Migasena 1972). In the Philippines, iron deficiency has also been identified as the principal cause of anemia among preschool children and

Table 4. Prevalence of protein-energy malnutrition (PEM) in preschool children in Southeast Asia.

Country	Severe PEM[a] (%)	Moderate PEM[b] (a)	Source
Indonesia	11–20[c]		Sajogyo (1974) cited by Lie Goan-Hong
Malaysia (peninsular)	0.2-5.7	5–32	Chong (1976)
East Malaysia	3.8–8.8	56–74[d]	Anderson (1967a, b, c)
Philippines	5.8 (4–8.3)	25 (21 –31)	Nutrition Center of the Philippines Operation Timbang (1976)
Thailand	2–8	26–38	Valyasevi (1975)

[a] Weight for age <60% of standard. [b] Weight for age 60–70% of standard. [c] Includes moderate PEM. [d] Includes mild PEM.



4. Vitamin A status of Ulu Rening subjects (rural Malaysia). Source: Ng and Chong (1977).

pregnant women (Marzan 1976). Such a picture is characteristic of the entire region.

Vitamin A deficiency

In Southeast Asia, xerophthalmia due to lack of vitamin A is a common cause of blindness in young children. It was the cause of blindness in half of 675 children surveyed in Surabaya (Saroso 1971). Xerophthalmia often accompanies severe PEM, and the majority of severe PEM cases seen in Indonesia are associated with this condition (McLaren 1975).

Recent nutrition surveys carried out in Malaysia (Peninsular and Sarawak) show that xerophthalmia is common in rural children. Measurement of the levels of vitamin A in blood serum samples taken in two rural communities revealed that, although 32% of preschool children and 16% of school children had low serum vitamin A levels, the levels in adults were comparatively satisfactory (Fig. 4; Ng and Chong 1977).

Xerophthalmia is uncommon among children with PEM in Uganda, West Africa, and the West Indies because the children's staple foods include plantain, maize, and red palm oil. The latter two are rich sources of Beta-carotene. In contrast, rice, the staple in Southeast Asia, is devoid of the provitamin A (McLaren 1975). Despite their abundance, carotene-rich, green leafy vegetables are not usually part of the diets of young children in Southeast Asia. For this reason, plant geneticists have been asked to develop a strain of rice with a little carotenoid pigment (McLaren 1975).

Thiamine deficiency

Throughout rural Southeast Asia, small-scale power mills are rapidly replacing home-pounding as a method of milling rice. Machine milling, unlike home-pounding, removes the thiamine-rich outer layer of the rice grain. In Thailand this is aggravated by the custom, still practiced in the rural areas, of cooking rice in excess water and discarding the water. The water-soluble vitamins are thus lost. As a consequence, many lactating women suffer from peripheral neuropathy, and their milk is liable to be deficient in thiamine, which may lead to infantile beriberi. In Malaysia, studies conducted on the red-blood-cell enzyme transketolase, which is dependent on the active form of the vitamin thiamine pyrophosphate for co-enzyme function, indicate that between 21 to 36% of apparently healthy subjects may be biochemically deficient in this nutrient (Chong 1976). However, the thiamine levels in the breast milk of rural lactating mothers attending a health center did not appear to lack the vitamin, presumably because of vitamin supplementation (Division of Nutrition, I.M.R. Annual Report, 1971).

Endemic goiter

Endemic goiter is still prevalent in many areas of the region. Thirty to 90% of the inhabitants of 10 hilly provinces in north and northeast Thailand were found to have goiter (Amorn Nondasuta 1972). A goiter survey in Malaysia in 1970 (Polunin 1971) found a high prevalence of visible goiter in the various rural ethnic groups (Table 5). In general, the prevalence of goiter increases as one goes from the lowlands toward the more hilly inland regions, and its endemicity is associated with a low intake of marine fish and low levels of iodine in the soil, and hence in the drinking water and crops of certain regions.

PATTERNS OF FOOD AVAILABILITY AND CONSUMPTION

Table 6 shows the per capita availability of the various food groups in grams of edible portions per day for the four nations in the region. Table 7

Table 5. Prevalence of endemic goiter in Malaysia (Polunin 1971).

Location	Ethnic groups	Grade 2 & 3 thyroid (%) in 15-year-olds
Peninsular	Malay	25
	Chinese	13
	Indian	35
	Orang Asli	48
Sarawak	Land Dayak	22
	Iban	51
	Kejaman	55
	Chinese	19
	Malay	3
Sabah	Dusun	27
	Orang Sungei	27
	Malay	46
	Chinese	21

Table 6. Food availability in Southeast Asia (grams of edible portions per capita per day from Food Balance Sheets).

Food groups	Food (g) per capita per day						
	Indonesia (1972)[a]		Malaysia (1970)		Philippines (1973)[a]		Thailand(1972)
			Peninsular	East			
Cereals	339	(367)	359	346	369	(349)	482
Rice	290	(292)	291	291	251		482
Maize	48	(75)	14	20	86		
Wheat flour	1	–	54	35	32		
Roots and tubers	187	(124)	78[b]	32[b]	84	(30)	185[b]
Sugar	20	(23)	82	64	50	(27)	30
Pulses and nuts	17	(8)	10	6	4	(7)	16
Vegetables and fruits[c]	Not available	47)	172	141	193	(200)	359
Fish	25	(30)	25	25			38
Meat and poultry			33	37	156	(84)	
					(fish & meal)		
Eggs	8	(8.4)	21	10	10	(11)	1
	(meat & eggs)						
Milk (as powdered milk)	0.7	(0.6)	2.6	1	1.3	(1.3)	1.8
Fats and oils (separated)	15	(11)	22	29	13	(13)	12

[a]Figures in parentheses are derived from Food Consumption Surveys 1969 for Indonesia; 1974 for Luzon, Philippines [b]Includes coconut [c]Includes bananas.

shows the total calories available per person per day, and the percentage of calories contributed by the various food groups. Table 8 shows the availability of protein per person per day, and the percentage of protein derived from these food sources.

These data were derived from food balance sheets, but in some nations they were also supplemented with data from household food consumption surveys. Because of the lack of uniformity in the data, the terms "food availability" and "food consumption" are used interchangeably. How reliable the data presented are is difficult to establish. This is underscored by the well-recognized inadequacies of the food balance sheet approach to nutritional assessment, as it gives no clue to food distribution within a population, and it is difficult to estimate postharvest losses of crops. The data also implicitly assume that current statistics for agricultural production are satisfactory. This is certainly not likely, because agricultural statistics in developing countries tend to be biased toward those food crops that figure prominently in trade, and it may not be possible to account for those items grown in home gardens or sold at the village level. Despite these shortcomings, the data presented in Tables 6, 7, and 8 can still give a rough picture of the pattern of availability of food, and serve to highlight the relative importance of the major food groups in the diets of the region.

Table 7. Daily per capita energy supplies.

Country	Total calories	Calories supplied (% of total)							
		Rice	Tubers and roots	Maize	Wheat	Sugar	Visible oils and fats[a]	Pulses and nuts	Others
Indonesia									
(National Socioeconomic Survey 1969–70)									
Java-Madura	1730	54	10	18	—	4	5(13)	2	7
Outer Islands	2075	61	7	8	—	5	6(15)	3	10
(Food Balance Sheet, 1972)	1794	58	14	9	—	5	7(13)	4	3
Malaysia									
(Food Balance Sheet, 1970)									
Peninsular	2172	48	2	2	9	12	8(18)	1	19
East	2020	52	2	4	6	10	12(21)	1	13
Philippines									
(Food Balance Sheet, 1973)	2109	44	4	15	5	9	5(13)	1	17
	1825[b]	73 (includes maize)	3	—	—	5	5(10)	1	13
Thailand									
(Food Balance Sheet, 1972)	2579	68	12	—	—	4	2(14)[c]	4	10

[a]Figures in parentheses refer to percent of total calories from all fats. [b]1974 Food Consumption Survey, all Luzon. [c]Scrimshaw et al (1973).

Table 8. Protein availability per capita per day (expressed as a percentage of total).

Country, region	Total (g)	Animal protein (%)	Available protein (% of total)									
			Rice	Roots and tubers	Corn	Wheat	Pulses and nuts	Fish	Eggs	Milk	Meat	Others
Indonesia (1969–70)												
Java-Madura	38	17	52	Included under rice	21	—	6	14	—	—	3[a]	4
Outer Islands	50	29	52		9	—	7	24			5	3
Food Balance Sheet (1972)	39	18	53	5	11	—	14	13	0.2	1.8	3	—
Malaysia (1970)												
Peninsular	52	37	38	4	3	12	3	17	5	4.6	11	—
East	46	36	42	6	5	9	2	18	3	2.1	13	—
Philippines												
Food Balance Sheet (1973)	54	39	34	1	14	6	1	18	2	2.4	15	—
All Luzon (Food Consumption Survey, 1974)	49	30	59 (includes maize)	1	—	—	3	27	2	1.8	[b]	6
Thailand (1972)	58	30	53	3	—	—	6	14	1	—	16	7

[a] Includes eggs. [b]Included under fish

Cereals

Despite the ethnic cultural diversity, rice is the staple food throughout the region. Between 250 and 290 g of rice is available per person per day; this is often supplemented with other staple foods such as tubers, roots, corn, and wheat flour. The sole exception is Thailand, where the per capita availability of rice alone is about 482 g/day. In all countries surveyed, rice is the major source of energy and also supplies between one-third to over one-half of the total daily available protein.

Roots and tubers

Although roots and tubers are eaten throughout the region, they play a more prominent role in the energy supply of Indonesia and Thailand, contributing 14% and 12%, respectively, to the total calories available. While cassava appears to be the main tuber eaten in Thailand, both cassava and sweet potatoes are consumed in Indonesia (Lie 1976).

Corn and wheat flour

Corn (maize) contributes a substantial proportion of the total available energy and protein in Indonesia and the Philippines. In Java-Madura, the household food consumption survey showed that 18% of the energy supply and 21% of the available protein are derived from maize, while the Philippines food balance sheet showed that maize contributes about 15% toward the daily supply of both energy and protein. (Corn comprises more of the diet in east Malaysia than in peninsular Malaysia, while no data seem to be available for the consumption of maize in Thailand.)

As for wheat, the figures for the national per capita daily availability indicate that little wheat flour is eaten in either Indonesia or Thailand. Malaysia has the largest per capita wheat-flour consumption, chiefly in the form of wheat noodles or bread.

Sugar

On a per capita basis, the consumption of sugar is highest in Malaysia, followed by the Philippines, Thailand, and Indonesia. Sugar provides about 10% of the energy supply for Malaysia and the Philippines, according to food balance sheet data.

Pulses and nuts

Legume proteins complement the protein in rice. Although legumes do not contribute significantly to total calorie intake in the region, they are an important source of proteins. They are mainly mung beans in Thailand and soybeans and groundnuts in Indonesia. In comparison, legumes appear to play a relatively minor role in the diets of Malaysia and the Philippines, where fish is the more important protein complement.

Fish

Fish are the principal sources of animal protein in the region, providing 24% of total protein in the Outer Islands of Indonesia, around 18% in both Malaysia and the Philippines, and 14% in Java and Thailand.

Meat and poultry

Meat and poultry are other important sources of animal protein, but because of their cost, their nutritional role is secondary to that of fish. In Indonesia, only a meager 4% of the overall protein supply is derived from meat, including eggs. Considerably more meat, i.e., between 11 and 16%, is consumed in other Southeast Asian countries. Only in Thailand is meat apparently more important than fish as the main source of animal protein. Islam forbids the consumption of pork, and this source of animal protein is thus not available to the region's Muslim population. In contrast, the Balinese in Indonesia are mostly Hindus who eat pork frequently, which may account for the rarity of PEM among children in Bali (Sutedjo 1971).

Eggs and milk

Together, eggs and milk provide about 10% of the total available protein in peninsular Malaysia, and about 5% in east Malaysia and the Philippines. Malaysia has the highest consumption of eggs and milk, which are insignificant foods in the Thai and Indonesian diets.

Oils and fats

Oils and fats consist of the visible oils, principally of vegetable origin, and invisible fat. A wide disparity exists in their consumption, varying from 12 to 29 g per person per day. The contribution of all fats, i.e., both visible and invisible, as a percentage of the total available calories seems low on the whole (within parentheses in Table 7).

NUTRITIONAL ADEQUACY OF SOUTHEAST ASIAN DIETS

The diet patterns of Indonesia, Malaysia, the Philippines, and Thailand are now considered for their nutritional adequacy in relation to the scale of requirement for per capita calories and protein recommended for East and Southeast Asia by the Food and Agriculture Organization and the World Health Organization (Sukhatme and Basu 1972).

Although the four nations under consideration have proposed separate national per capita per day requirements for calories and protein, the adoption of all or any one of the standards to represent the region poses practical difficulties. The per capita requirements for calories and protein here proposed – 2,130 calories and 47 g of protein per capita per day

Table 9. Nutritional adequacy of Southeast Asian diets (per capita availability/day).

Country, data source	Total calories	Calories as % of requirement	Protein (g)	Protein as % of requirement	Protein-calorie ratio	Animal protein (%)
Recommended per capita daily requirements for East and Southeast Asia (Sukhatme 1972)	2130		46.8		8.8	—
Indonesia						
National Socioeconomic Survey, 1969–70						
Java-Madura	1730	81	38	81	8.8	17
Outer Islands	2075	97	50	101	10	29
Food Balance Sheet (1972)	1794	84	39	83	8.7	18
Malaysia						
(Food Balance Sheet, 1970)						
Peninsular	2172	102	52	111	10	37
East	2020	95	46	98	9	36
Philippines						
All Luzon (Food Consumption Survey, 1974)	1825	86	49	105	10.7	30
Food Balance Sheet (1973)	2109	99	54.4	116	10.3	39
Thailand						
(Food Balance Sheet, 1972)	2579	121	57.8	124	9.3	30

(Sukhatme and Basu 1972)–may offer the advantage of some margin for safety, bearing in mind the controversy that still surrounds the question of protein requirement relative to calorie intake (Scrimshaw 1976, Garza et al 1976). The adequacy of the diets, with special reference to the availability of calories and protein in indigenous foods, can be seen in Table 9.

The following conclusions can be drawn from the table:

1. A serious deficiency in both calories and protein (both in the quantitative and qualitative sense) exists in Java-Madura, Indonesia, suggesting that the problem of malnutrition there is acute.

2. For the Philippines and the Outer Islands of Indonesia, a calorie deficiency exists in juxtaposition with a marginal overall excess of protein, if existing estimates of protein and calorie requirements are applicable.

3. While peninsular Malaysia shows a slight surplus of both calories and protein, east Malaysia shows marginal deficits in both protein and calories.

4. Thailand, which is the sole net exporter of rice in the region, appears to have a net surplus of both calories and protein at per capita levels.

The availability and consumption of calories and protein at national per capita level, however, conceal variations among the different socioeconomic classes and geographical zones. In Java-Madura, where severe deficiencies in both calories and protein have been revealed, it can be expected that the economically underprivileged, who comprise 56%, or 46.2 million of the total population, are likely to have much less food available to them than indicated in the already low national averages. Indeed, by Sukhatme's standard, the urban poor in Java-Madura consume only 49% and 47% of their calorie and protein requirements, respectively; for the rural poor, the per capita consumption of calories and protein is 53% and 51%, respectively, of the theoretical requirements (calculated from the data given in Lie 1976).

In countries with an apparent adequacy or even a slight surplus of protein (although lacking sufficient calories) – i.e., the Outer Islands of Indonesia, east Malaysia, and the Philippines – much of the population may still be protein-deficient because of uneven food distribution. Such a possibility is more than adequately demonstrated in the 1974 Philippine Household Food Consumption Survey conducted in Luzon, which found that only 25% and 31% of the households had adequate energy and protein intakes, respectively. Moreover, the human body may use the dietary protein for energy purposes instead of for growth, repair, and other bodily functions.

The apparent per capita surplus of both calories and protein reported in Thailand is probably deceptive. The Nutrition Planning Working Group, which met in March 1975 on "National Policy on Food and Nutrition," cautioned that for a variety of reasons — uneven distribution of income, poor transport and storage, hoarding by merchants, and illegal exports — the "available" foods may not actually reach the consumers. Further evidence to support this view is shown by the large proportion of poor households that were defined by their inability to obtain the daily minimum requirements for energy and protein. The percentage distribution of such poverty households throughout Thailand was said to be 64% for the whole of Thailand, 77% in the northeast, 71% in the north, 72% in the south, and 54% in the central area (Thailand Nutrition Planning Working Group, 1975).

The fact is that the poorer segments of the population are the most nutritionally deprived, and the ecological constraints and unequal pattern of socioeconomic development tend to perpetuate hunger and malnutrition.

MEETING NUTRITIONAL REQUIREMENTS BY AGRICULTURAL AND SOCIOECONOMIC MEASURES

Even if there were no food shortages in the region, the total food supply would have to be increased by about 3.6 to 4%/annum to keep pace with the population increase of over 3%/annum. To overcome the nutritional deficiencies described, considerably more than the theoretical minimum of a 3.6% annual increase in food production must be achieved if current requirements and the demands from an expanding population are to be met.

In the essay "Nutrition and the Future of Mankind," Behar (1976) states that the vicious cycle of malnutrition and its effects on health and socioeconomic development trap the economically deprived and perpetuate social injustice, and he points out that malnutrition is a consequence of such injustice. Nowhere else is the moral and social issue better illustrated than in Indonesia, where large groups of people who have lived all their lives with chronic malnutrition no longer regard it as an illness (Prawirosudirdjo 1971).

At the International Conference on Nutrition, National Development, and Planning, held at the Massachusetts Institute of Technology in 1971, Call and Levinson (1973) identified two basic, distinct factors in malnutrition, namely, the effects of inadequate food intake and the resulting poor general health of young children. These two factors, in turn, are associated with family purchasing power, nutritional knowledge and the health beliefs of a child's mother, the nutrient content of foods eaten, lack of adequate health services, and the poor social and physical milieu. Call and Levinson also discussed two main types of intervention programs for improving nutrition — the short-term palliative *targeted* approach, such as child-feeding programs, and the long-term *blanket* approach through increased agricultural and health inputs.

Examples of these two approaches are found in the region. In the Philippines a remarkable target program, "Operation Timbang," has extended food assistance through the locally developed "Nutripaks" (satisfying half of the daily protein and energy requirements) to 200,000 children suffering from third-degree malnutrition, identified by a nationwide child-weighing campaign. In Thailand the Kaset Infant Food, based on rice flour, full-fat soy flour, and a vitamin-mineral premix, developed by the Institute of Food Research at Kasetsart University, is gaining acceptance as a ready source of weaning and postweaning food (Buchanan 1975).

In Malaysia, the blanket approach is seen in the vigorous governmental pursuit of the New Economic Policy, which is aimed at raising the income and the quality of life for the agricultural sector (paddy farmers, fishermen, rubber and coconut smallholders). The policy provides for a network of programs, including new irrigation schemes for double-cropping of rice; governmental support for a minimum paddy price; government-operated grain-drying, storage, and milling complexes; clearing and development of new agricultural land; provision of credit; agricultural extension; and improved processing and marketing facilities.

Clearly, combating malnutrition requires a two-pronged targeted and blanket approach, and in this campaign the contribution of the International Rice Research institute (IRRI) knows no national boundaries; it has extended the Green Revolution to the countries in the region by introducing improved rice varieties and rice technologies. Already much of the rice-growing land in Southeast Asia has been planted to improved varieties: 56% in the Philippines, 38% in Malaysia, 30% in Vietnam, 18% in Indonesia, and 5% in Thailand (IRRI 1975).

The fight against chronic malnutrition is no longer regarded as solely the concern of public health authorities; it is now considered a socioeconomic, developmental, and moral issue requiring the combined efforts of economic and health planners, nutritionists, food scientists, and agricultural and social scientists. Furthermore, the need for full governmental support in reducing the disparities in living conditions between the economically privileged and the socially disadvantaged to improve the quality of life is fundamental to solving the problem of malnutrition in the region.

Fortunately, there does not seem to be any lack of appreciation within government circles in Southeast Asia of the relationship between the multitude of ecological factors and malnutrition. The increasing tempo of technical and economic cooperation among the nations in this region, and the interaction such as that which occurred at this workshop, can only augur well for the future of Southeast Asia.

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COMMENTS ON

Malnutrition, food patterns, and nutritional requirements in Southeast Asia

NEVIN S. SCRIMSHAW

Dr. Chong has provided a comprehensive review of dietary patterns, nutrition problems, and nutritional needs of various Asian populations, with special emphasis on Malaysia. Even in Asia associated nutrition problems are due not so much to an absolute shortage of food as to its distribution, and distribution of food represents the heart of the problem of hunger.

The discrepancy between average caloric requirements by FAO/WHO estimates and average caloric intake is the highest for any major geographic region. The difference of approximately 230 calories between the two values does not appear large. Only when the effect of income distribution on caloric intake is examined does that difference become significant. The 9% who are relatively affluent use more dietary calories than they need, while 83% of the population has progressively less than physiological requirements. The former cannot eat all this extra food, but rather are wasteful in their consumption.

These projections are based on aggregate data for countries from the FAO Food Balance Sheets and are, of necessity, unsatisfactory approximations. They do, however, illustrate an important principle: the proportion of undernourished or malnourished cannot be predicted from average per capita data unless the distribution is also examined. With equal reservations, the same data and method of calculation can be applied to comparison of protein intakes and requirements.

The distribution of protein might be expected to be at least as much distorted because people eat much more protein than they need if they can afford to do so, and this is indeed the case. However, the real significance of this is not apparent until the poor quality of the total protein in the diets of the low-income populations is taken into account. Animal protein intake in Asia is even more unevenly distributed by income. The coefficient of change in consumption with income is 0.10 for calories and 0.18 for protein; for animal protein it is much higher — 0.65.

The net protein utilization (NPU) of egg, meat, or milk, when consumed at requirement intake levels, is only about 60%. A good mixed diet has an NPU of about 90% of such animal protein, and the poorest cereal diets have perhaps a protein value approximately half that of animal protein. A proportion of total dietary protein calories to total dietary energy of about 9% with animal protein is equivalent to more than 13% with the latter.

At requirement levels, the NPU of rice is very close to that of animal protein and provides about 7% of protein calories. Even when caloric needs are met that is still insufficient protein from this source alone to provide a safe margin. Diets that are predominantly rice, like those based on other cereals, need to contain another, more concentrated source of protein, either of vegetable origin such as legumes and oilseeds, or of animal origin.

Without losing a sense of proportion in overall priorities, this workshop should examine closely the validity of recent attempts to point out that, at present, in most developing countries, feeding people receives a low *de facto* priority in private and public sector policy. For example, the arguments put forth by Frances Moore Lappe and Joseph Collins in *Food first*, that nearly all countries could feed their populations if this were made an overriding policy objective, have validity. Their indictment of national and international policies that are designed to maximize private or government financial gain, or that allow the priorities of industrialized countries to dominate the strategies of less developed countries in agricultural and marketing planning, has considerable substance.

National policies that give priority to production of food by small farmers and an adequate return for their efforts, rather than policies directed at the generation of foreign exchange or obtaining maximum incomes for the elite, could change the food situation markedly. In other words, the serious food and nutrition considerations outlined by Dr. Chong need to be taken into greater account in sector policy and national development planning.

Sources of growth in Asian food production and an approach to identification of constraining factors

ROBERT W. HERDT and RANDOLPH BARKER

THE DEVELOPING COUNTRIES of Asia, excluding the People's Republic of China, have 1.2 billion people, approximately one-third of the world's population. Provision of adequate food for these people has been a chronic concern of the governments of the area and others who care about human welfare in Asia. In this paper, we summarize the current food situation in the region and the prospects for the future.

The paper has three parts: the first section discusses the current level of food production in the region, and the production changes that have occurred over the period from 1952 to 1972. The second section examines the potential for increasing production of cereal grain. The third section discusses the prospects for future growth in output of the dominant cereal, rice, with particular emphasis on determining what potential for increasing production is offered by currently available technology and the reasons why that potential has not been achieved.

CURRENT FOOD ADEQUACY AND RECENT TRENDS[1]

The food balance sheet approach is one of the few practical ways of quantifying food availability on a national basis. It is a simple accounting of food production, exports, imports, and stock reduction, divided by population to give per capita availability. This is sometimes adjusted for feed, seed, and waste to indicate apparent consumption. Where data on food stocks or supply changes are not available, averaging availability over several years results in acceptable estimates.

Figure 1 shows the apparent daily per capita consumption of food calories in 16 Asian countries. Because data on food stocks are not available for all countries, the average for 1963–67 was compared with the

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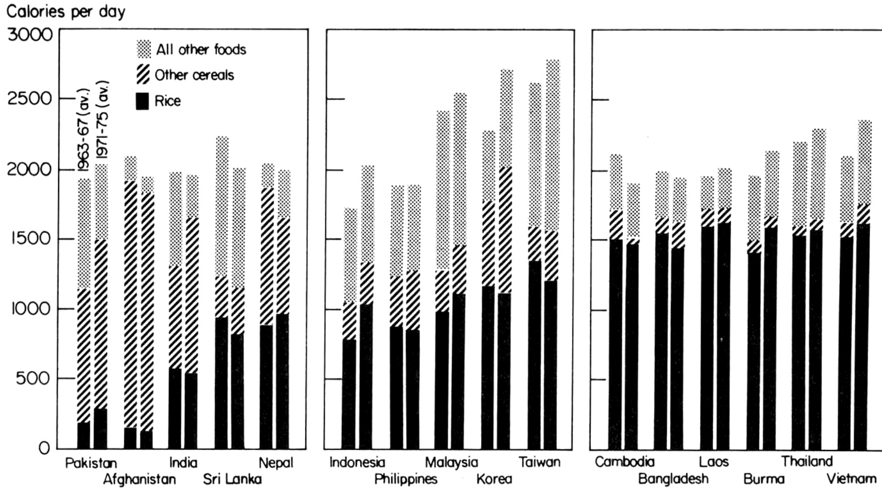
[1]The data in this section draw on materials prepared by Randolph Barker and Bruce Johnson in the *Asian Agricultural Survey 1976, Rural Asia: Challenge and Opportunity (1977).*



1. Apparent per capita daily calorie consumption, 1963-67 and 1971-75 in 16 Asian countries.

average for 1971–75. The difference shows the change in consumption levels between the two 5-year periods.

The general impression is one of very little change between the two periods. All foods other than cereals provide less than about half of the diet in all countries except Sri Lanka, Malaysia, Indonesia, and Taiwan. Except in Afghanistan, Pakistan, and parts of India, rice contributes an appreciable fraction of total calories in all Asian countries, particularly in the mainland Southeast Asian countries of Kampuchea (Cambodia), Bangladesh, Laos, Burma, Thailand, and Vietnam.

In most of these countries, approximately 2,000 calories are available per person per day, approximately equal to the level required for maintenance. However, one must recognize that, because of inequitable income distribution, there is a wide variation in food availability within the countries represented. It is almost certain that substantial proportions of the populations of those countries have inadequate diets. In that light, the failure to achieve greater increase in food production during the period 1963–75 is disheartening.

The data in Table 1 give some insight into why per capita food availability has not increased more rapidly. The table shows the annual rates of growth in population in food crop and livestock production, and in domestic demand between 1952 and 1973, as calculated by the Food and Agriculture Organization (FAO), for the World Food Conference of 1974. In these data, demand is estimated on the basis of the equation:

$$D = P + eY,$$

where D, P, and Y represent the rates of growth of food demand, popula-

Table 1. Population, food supply, and demand for food. 1952-72. Source: United Nations 1974.

Country	Growth rate (%) per year[a]		
	Population	Food[b] production	Domestic demand for food[c]
Afghanistan	1.9	1.7	2.2
Bangladesh	3.5[d]	1.6[d]	n.a.[e]
Burma	2.2	2.4	3.3
Korea (S)	2.7	4.8	4.7
India	2.1	2.4	3.0
Indonesia	2.5	2.0	2.6
Malaysia (W)	3.0	5.2	4.3
Nepal	1.8	0.1	2.1
Pakistan	3.0	3.0	4.2
Philippines	3.2	3.2	4.2
Sri Lanka	2.5	3.6	3.1
Thailand	3.1	5.3	4.6

[a]Exponential trend 1952-72 [b]Food component of crop and livestock production only (i.e. excluding fish production) [c]Calculated on the basis of growth of population and per capita income and estimates of income elasticity in FAO Commodity Projections, 1970-80 Rome Italy 1977 Total food including fish [d]1962-72 [e]Not available.

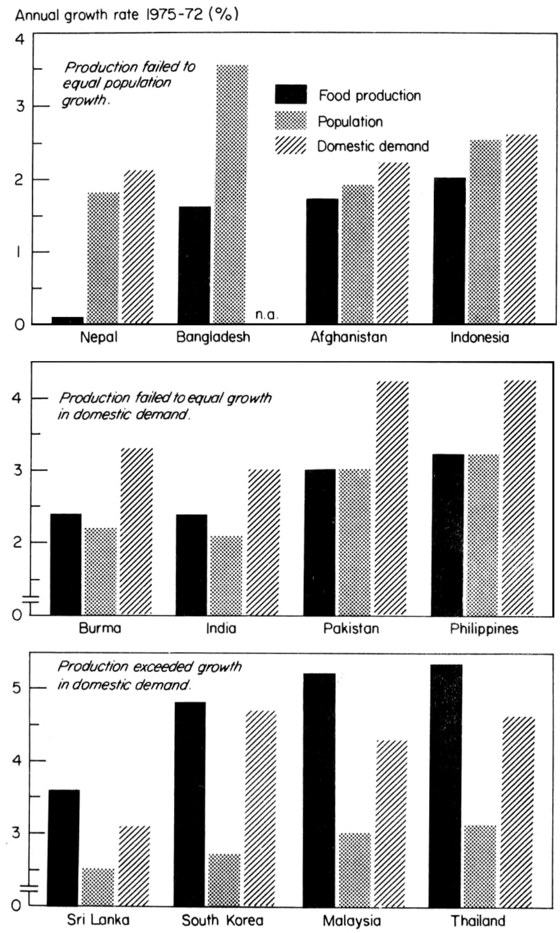
tion, and per capita income, respectively, and e represents the income elasticity of demand for food. The data are shown graphically in Figure 2 with the countries divided into three groups.

In Nepal, Bangladesh, Afghanistan, and Indonesia, population grew more rapidly than food production during the 1952–72 period. As a result, Nepal reduced its export of cereals, and the three other countries increased their imports. In Burma, India, Pakistan, and the Philippines, food production increased at a faster rate than population, but demand outstripped both. In those countries, as well as in the first four cited, there was upward pressure on prices that could only be offset by imports or, in the case of Burma, by reducing exports.

The third group of countries enjoyed a rate of production increase that exceeded their growing rates of demand. Under these conditions, they could increase their exports (Thailand), decrease imports (Malaysia), or permit real food prices to move downward, thereby benefiting consumers.

Unfortunately, this favorable picture has been reversed by bad weather in Sri Lanka since 1972. In all these countries, moreover, the long-term trends hide substantial fluctuations, the most extreme of which have occurred since 1972. One result of these fluctuations is a strengthening of the desire for national self-sufficiency in food.

These data indicate that, while food production has increased between 1.6 and 5% per year in various countries, with substantial increments in cereal grains, these increases have been sufficient to keep up with demand in only a few countries. In the others, there has been an unavoid-



2. Growth rates of food production, population, and domestic demand for selected Asian countries. 1952-72. Source: United Nations 1974.

able increase in dependence on imports, reduction of exports, or an upward pressure on food prices. In this context, it is important to examine the growth that has occurred to determine its sources and ask whether it can be enhanced in the future.

POTENTIAL FOR INCREASED PRODUCTION OF FOOD GRAINS IN ASIA[2]

Agricultural production can be increased by expanding the area cultivated or by raising the productivity of land already under cultivation. In South and Southeast Asia before 1960, the opening of land to cultivation

Table 2. Growth rates of production, area and yield of rice for selected Asian countries, 1955-73.

Country	Annual compound growth rate (%)					
	1955-65			1965-73		
	Production	Area	Yield	Production	Area	Yield
Pakistan	4.46	3.25	1.21	7.55	1.11	6.44
Malaysia (W)	5.38	3.41	1.97	6.39	4.67	1.72
Sri Lanka[a]	4.98	2.88	2.10	5.53	3.16	2.37
Indonesia	1.41	0.90	0.51	4.60	1.84	2.76
Philippines	2.35	1.15	1.20	3.40	0.86	2.52
India	2.56	1.26	1.30	2.47	0.61	1.86
Thailand	3.46	1.73	1.73	2.07	1.84	0.23
Korea (S)	5.98	1.08	4.90	1.70	-0.12	1.82
Nepal	6.53	-1.71	8.24	1.60	3.02	-1.42
Bangladesh	3.08	1.10	1.98	1.05	0.60	0.45
Burma	2.87	1.93	0.94	0.84	0.13	0.73
Taiwan	3.50	-0.03	3.53	0.15	-0.30	0.45

[a] Second period growth rates cover 1965-72.

provided the principal source of increased production. New lands were opened up at a pace roughly the same as the growth in the agricultural labor force.

The gradual closing of the arable land frontier after 1960 — more pronounced in paddy rice than in upland crops — necessitated a shift toward the use of modern, yield-increasing agricultural inputs. The speed with which this transformation can occur determines the degree to which agricultural production can keep pace with population growth and generate the needed food surpluses. In this section, we examine the changes in production methods, area planted. and yields of rice, wheat, and maize over the past two decades; for rice, we will measure the contributions of greater use of fertilizer and better irrigation techniques to crop yield.

Growth in rice production, 1955–73

Rice production accelerated in Pakistan, Malaysia, Sri Lanka, Indonesia, and the Philippines in the late 1960s compared to that in the previous decade (Table 2). In South Korea, Taiwan, Bangladesh, and Burma, it slowed perceptibly, while in India the rate of increase was nearly constant. The changes in rates of production growth can perhaps be understood best by examining how the changes in land area and production methods contributed to output growth.

In the mid-1950s, rice yields in South Korea and Taiwan were about 3 t/ha, twice the 1.5 t/ha being obtained in South and Southeast Asian coun-

[2] The contributions of Sumalee Apiraksirikul and Donato Antiporta in preparing this section are gratefully acknowledged.

tries except Indonesia and Malaysia, where yields averaged about 2 t/ha. By the mid-1960s, the differential was even greater because of the more rapid yield increases in Korea and Taiwan. In the period since 1965, however, Pakistan, Indonesia, Sri Lanka, and the Philippines have registered yield increases in excess of 2% annually and have narrowed the gap. Rates of yield increase in South Korea and Taiwan were substantially lower during the 1965–73 period than in the previous decade, suggesting that relatively little "slack" remained. In South Korea, however, beginning in 1971, the introduction of a new generation of high yielding rice, obtained by crossing indica and japonica strains, significantly raised the yield ceiling and the rate of growth of rice yields has again accelerated.

Between 1955–65 and 1965–73, there was a decline in the importance of newly cultivated land in the increased annual rice output. The percentage of this output attributable to an increase in land area dropped from 1.3 to 0.9%/year for South and Southeast Asia as a whole. These rates overstate the amount of land brought into production because official government statistics normally report gross rather than net area, and the growth in area has likely come about, to some degree, from the expansion of the area devoted to double-cropping. Still, by the early 1960s it was becoming apparent that in many Asian countries there was little remaining land that could be developed into rice paddies at reasonable cost. To maintain the existing production trend (if not increase production), it was essential to introduce a yield-increasing technology.

To what extent were increases in yield able to compensate for the slower rate of area expansion? Pakistan had the fastest rate of yield increase (Table 2). There, rice is grown under conditions of controlled irrigation in a dry climate ideally suited to the new varieties. The increase in yields exceeded 6%/annum, and total rice output grew at a rate of 7.5%/annum. This was associated with a remarkably rapid increase in the percentage of rice planted to high yielding varieties, from less than 1% in 1967–68 to 42% in 1973–74.

In Burma, Bangladesh, and Thailand, where the bulk of the rice is grown in the major river deltas, the slowest rates of growth were experienced. The development of rice production in these deltas during the latter part of the 19th century resulted in substantial surpluses, and brought Burma and Thailand to prominence as rice exporters. It is paradoxical that the environment that favored surplus rice production in the earlier period is not suitable for the new varieties. The major deterrent to the adoption of the new varieties and use of fertilizer in these three countries and elsewhere has been the lack of water control. Either too little or too much water can seriously affect the growth of the new varieties. Because they have shorter stems and shorter growing periods, modern rice varieties are frequently more sensitive than local varieties to flooding and drought. The risk of applying fertilizer and other additives is naturally increased under conditions where water supply to crops is not controlled, the situation prevailing in the large river deltas.

The experience of India taken as a whole has been intermediate between the extremes, but India's national average obscures the marked contrasts between different regions. Northern India compares favorably with Pakistan in both adoption of new varieties and yield gains, but in much of the waterlogged areas of eastern India, growth in yield has been slow. If they can irrigate, many farmers in these regions grow the new varieties and add purchased inputs during the dry season, but switch back to the traditional varieties during the wet, a behavioral pattern that reflects the importance of the physical environment.

Sri Lanka, Indonesia, and the Philippines all experienced growth in yield per hectare in excess of 2% between 1965 and 1973. These countries placed major emphasis on the development of irrigation and on expansion of the double-cropped area, with the result that the harvested area of rice grew at more than 1 %/annum, and in Sri Lanka and Malaysia, at more than 3 and 4%/annum, respectively.

Wheat

Wheat is the principal cereal in Pakistan, Afghanistan, and Northern India, where the introduction of high yielding, semidwarf varieties from Mexico had an impact different from that of the new varieties of rice.

The rates of increase in wheat production and yield in Pakistan and India in the period 1955–73 were particularly impressive (Table 3). In India, higher wheat production was associated with rapid increases in yield and expansion of area planted to new varieties. The rate of increase in yield in Pakistan was slightly higher than that in India, but the opening

Table 3. Growth rates of production, area and yield of wheat and maize for selected Asian countries, 1955–73.

Country	Annual compound growth rate (%)					
	1955–65			1965–73		
	Production	Area	Yield	Production	Area	Yield
		Wheat				
India	2.45	1.36	1.09	10.37	4.69	5.68
Pakistan	2.17	1.87	0.30	7.33	1.41	5.92
Afghanistan	0.19	1.07	-0.88	2.41	0.33	2.08
		Maize				
Thailand	27.81	23.58	4.23	9.86	8.35	1.51
Philippines	5.10	3.46	1.64	5.74	3.48	2.26
India	5.34	2.56	2.78	1.53	2 18	-0.65
Indonesia	3.47	3.32	0.15	0.46	-0.69	1.15

of new lands was not nearly as rapid. Production in Pakistan went from an average level of 4.2 million t during 1963–67 to nearly 7.3 million t in the 1970–74 period.

In India as a whole, wheat production more than doubled between 1963–67 and 1970–74, rising from 10.9 to 22.4 million t. In the earlier period, wheat output was only 24% that of rice, but in the latter period the average wheat crop was nearly 40% as large as the rice crop. In fact, the 12.5 million-t increase in wheat production accounted for over half the total increase in Indian cereal production between 1963–67 and 1970–74, and was the major factor responsible for reducing India’s cereal imports from an average of 8.2 million t during 1963–67 to 3.5 million t in the 1970s. In Bangladesh, wheat production more than doubled between 1963–67 and 1970–74, although it remained a minor crop compared to rice.

Increases in wheat yield in Afghanistan during the 1965–73 period were moderate, but they still represent a significant reversal of a declining trend (Table 3). This reversal made possible a tenfold increase in the rate of growth of wheat output, from a mere 0.2% between 1955 and 1965 to 2.4% in the following decade, despite the lower rate at which new land was planted to wheat.

Thus, we can see that, unlike rice which encountered a land constraint, wheat production was increased both by bringing new land under cultivation and by introducing new seed strains with greater yields. As the new varieties took hold in the Punjab and other parts of northern India, they spread rapidly to the southeast, down the Gangetic Plain into eastern Uttar Pradesh, and to the northern portions of Bihar, West Bengal, and Bangladesh — wherever water was available. In some cases, wheat replaced inferior grains such as corn, sorghum, or millets and, to a lesser extent, pulses. Because of its short growing period, it was possible to plant wheat immediately after the rice harvest in other areas where only one crop had been grown before.

Maize

Maize is an important crop in India, Indonesia, the Philippines, and Thailand. In all of these countries except Thailand, the bulk of the maize crop is consumed domestically as a food grain.

Pakistan, the Philippines, and Thailand registered significant increases in maize output between 1963–67 and 1970–74 (Table 3). There has been no major technological breakthrough for this crop. Much of the increase in output has been due to expansion of cultivated land although there has been steady progress in increasing yield per hectare, particularly in the Philippines. Downy mildew, a fungus disease, continues to be a major impediment to increased maize yields.

The most spectacular growth in maize production has been in Thailand, There, the development of an export market and the opening up of new areas to production were stimulated by the construction of new and improved highways. Essentially all of the Thai crop is exported as livestock feed, principally to Japan and Taiwan.

Reasons for increased rice production

The contributions of irrigation and fertilizer to increased rice production are here examined in more detail. The first step in the analysis is to distinguish in more detail the contribution of cultivated area and that of yield per hectare. Changes in use of croplands arise from increases in the total land brought under cultivation, or from double-cropping the land already cultivated. For purposes of study, yield increases can be separated into those due to a higher proportion of irrigated area and those due to greater use of yieid-increasing inputs such as new seed varieties and fertilizer. In our initial computation procedure, the first is directly calculated and the second obtained as a residual between the total and the first.

Following the above methodology we have examined the sources of output growth in the Philippines from 1955 to 1973 (Table 4). In the period between 1955 and 1965, the major factor in increased production was irrigation (double-cropping and land quality, included as "double-cropping" and "type of rice land" in Table 4), which accounted for 1.8 of a total 2.4% annual growth rate. Land-area expansion and seed-fertilizer were not very important. Between 1965 and 1973, the land-area factor became negative principally because of the decline in upland rice area,

The contribution of irrigation to the growth of output increased because the area double-cropped more than offset the decline in net area

Table 4. Growth rates of production, area and yield of rice and their components, Philippines, 1955 - 73.

	1955-73	1955-65	1965-73
	Annual growth rates (%)		
Production	2.78	2.41	3.24
Area	1.11	1.15	1.05
Yield	1.62	1.20	2.15
	Percentage points attributed		
Area			
Physical area	-0.18	0.28	-1.01
Double-cropping	1.29	0.87	2.06
Yield			
Type of rice land[a]	0.79	0.36	0.44
Fertilizer varieties etc.[b]	0.83	0.24	1.71
Fertilizer[c]	(0.85)	(0.32)	(1.47)

[a]Changes in the proportion of upland rainfed wet-season and dry-season irrigated [b]Calculated as a residual. [c]Calculated on the basis of 10 kg of yield for every 1 kg of fertilizer. Either the value in parentheses or the one above it should be used, but not both.

planted. New varieties of rice and modern chemical additives accounted for an output increase of 1.7%/annum.

Mellor (1976) has undertaken a similar analysis of food grain production in India, although his input classification is somewhat different. Nevertheless, there is similarity both in the magnitude of the reasons for the increased production of rice in the Philippines and of food grains in India. The new importance of fertilizer and irrigation as the major reasons for increased production in the 1965-73 period has been highly significant in both countries.

It is difficult to extend the analytical procedures followed in the Philippines to other countries because of lack of data on the double-cropped irrigated rice land. In calculating the contribution of fertilizer, Mellor's analysis assumes that 1 kg of fertilizer nutrient (nitrogen, phosphorus, or potassium) produces 10 kg of grain. Using this relationship, we computed the contribution of fertilizer for the Philippine situation. The values, shown in the last row of Table 4, compare favorably with the values obtained with the method of calculating fertilizer contribution as a residual.

In Pakistan, Sri Lanka, Indonesia, the Philippines, and India, increased yields per unit area cultivated have been the main source of output growth. In all but Sri Lanka, the use of fertilizer tripled from about 8 kg NPK/ha to 20 to 25 kg NPK/ha. In Sri Lanka, fertilizer use also tripled, from 25 to 72 kg NPK/ha, and contributed heavily to the increased yields.

The sources of production growth in Malaysia and Thailand stand in sharp contrast to the pattern in the five other countries. In Malaysia, the expansion of the land under irrigation was most significant, accounting for two-thirds of the added yield. In contrast, Thailand was the only country to follow the traditional pattern of increasing output by augmenting the rainfed rice area. The slow rate of change in unirrigated land use in the six other countries suggests that the expansion of rice production has principally been through double-cropping irrigated land rather than bringing new land into use.

FUTURE SOURCES OF GROWTH IN FOOD PRODUCTION

Our analysis has shown that Asian countries can be put into three broad categories in terms of their rice output performance over the past decade: 1) those that have been able to maintain a mean annual growth rate of 2% or more by combining expanded irrigation with increased use of modern varieties of seed and technology (India, Indonesia, Malaysia, Pakistan, Philippines, and Sri Lanka); 2) those whose growth rate has been slowed in major part by their inability to increase yields through extensive adoption of modern seed-fertilizer technology (Bangladesh, Burma, and Thailand); and 3) those whose growth rate has decreased,

Table 5. Use of modern rice varieties, irrigation, and fertilizer in 11 Asian countries, 1970–74.

Country	Total rice area (thousand ha)	Modern varieties (%)[a]	Irrigated rice area (%)	Fertilizer[b] (thousand t) National total	Applied to rice	Fertilizer (kg/ha of rice)	Fertilizer (kg/ha of arable land)[c]	Actual average yield (t/ha)
India	37,755	30	40	2,586	827[d]	21.9	17.2	1.7
Bangladesh	9,766	15	16	148	n.a.	n.a.	19.4	1.7
Indonesia	8,482	41	47	345	230[d]	27.1	26.3	2.5
Thailand	7.037	7	11	117	48[d]	6.8	11.5	1.9
Burma	4.985	7	17	41	24[d]	4.8	3.0	1.7
Philippines	3.488	62	41	202	75[d]	21.6	34.4	1.6
Vietnam[d]	2,713	31	15	174	n.a.	n.a.	59.6	2.4
Pakistan	1,518	40	100	362	36[d]	23.7	20.8	2.3
Nepal	1,200	19	16	10	n.a.	n.a.	7.1	1.9
Malaysia	771	36	77	196	n.a.	n.a.	74.3	2.5
Sri Lanka	604	55	61	138	41[d]	68.3	48.0	2.5

[a] 1974–75 data from Dalrymple (1976). [b] Tons of nutrient of N, P_2O_5, K_2O, 1970–74. [c] From Palacpac (1966) [d] Developed from data collected by R. Barker for Asian Development Bank, Second Asian Agricultural Survey [e] n.a. = not available.

apparently because they are approaching the limit of the yield potential of currently available technology (South Korea and Taiwan).

We assume that these latter two cases are sufficiently far advanced in terms of economic development so that acquisition of adequate food supplies will not be a serious problem. But the question of how growth in rice production will be sustained in the developing economies of South and Southeast Asia remains a critical issue.

Maximum possible yields

A decade ago, most of the countries in the region were just beginning to expand their use of fertilizer and other modern inputs. The situation in the early 1970s is depicted in Table 5. Modern seed varieties, fertilizer, and irrigation techniques had been adopted to a considerable degree in a number of countries. It appeared that much of the production potential of the technology had been exploited, but rice yields in the tropical Asian countries were still only between 1.6 and 2.5 t/ha. This seems low compared to the 6 to 8 t/ha that was hoped for during the first flush of enthusiasm for the semidwarf rice varieties (IRRI 1966).

This difference, or gap, between actual yields and theoretically potential yields has become the subject of substantial research effort (Herdt and Wickham 1975, Gomez 1976, IRAEN 1975). The conceptual model illustrated in Figure 3 forms the basis of the research. The difference between average national yields and the yield potential claimed by rice researchers is hypothesized as having two components, Gap I and Gap II.

The maximum possible yield of a variety is sometimes defined as the highest yield the variety has obtained at any experiment station, or during any season at one station. That definition has only limited applicability to the problem of increasing rice production on the farm. A more useful definition is the average yield of the variety, or set of similar varieties, when grown by the best available methods and with maximum inputs in trials on experiment stations throughout a region or country. Such a yield gives an idea of the capability of the variety under the favorable environments prevailing on most experiment stations, but does not reflect simply a single case of especially favorable circumstances. This is the concept used as the experiment station yield. Corresponding to this is the average yield that would obtain in farmers' fields using the same variety or set of varieties of grain, growing them by the best methods, and using maximum inputs to achieve the greatest possible yields – *potential farm yield.*

We hypothesize that, in Asia, the average rice farmer has a substantially poorer environment for growing rice than has the average experimental station. In addition to environmental differences, some technology from experimental stations may also be impossible to carry over to farmers. Therefore, even with the same variety, cultivating practices, and inputs, the potential farm yield, on the average, is lower than the experiment station yield. This difference is yield gap I. It is hoped that yield gap I will be small, because a large gap would imply that the technology being developed at the experiment station is not relevant to most farms. (Yield gap II is discussed in a latter section.)

It is impossible to measure yield gap I because we cannot accurately measure the average potential farm yield for a country. It is, however, possible to make some judgments about the experiment station yield that is attainable in the present state of rice technology. To do this, we examined reports on rice research in recent years from a number of major Asian rice-producing countries. The results are summarized in Table 6. For each country, we sought research data reporting yields of modern varieties grown in high inputs and good practices on a number of experiment stations for a number of years and seasons. Nearly all the available reports were for irrigated, lowland conditions, and the data in Table 6 include only those conditions.

The data suggest that under experimental conditions, with maximum fertilizer and good irrigation, the currently available rice technology is capable of producing yields averaging from about 4 t/ha in the wet season up to 6.8 t/ha in the dry season in various countries. Maximum economic yields would be somewhat lower, but comparing these levels to present farm yields of 1.6 to 2.5 t/ha (1970–74: last annual statistics available) suggests that considerable increase might be possible.

However, the importance of environmental conditions in determining

Table 6. Average maximum rice yields[a] recorded on experiment stations in some Asian countries, early 1970's.

Country	Wet season		Dry season	
	Experiments (no.)	Yield (t/ha)	Experiments (no.)	Yield (t/ha)
India (ICAR)	27	5.4	12	6.8
Bangladesh (BRRI)	n.a.	4.9	n.a.	6.6
Indonesia (CRIA)	10	4.8	12	5.9
Philippines (BPI-IRRI)	64	4.6	54	5.9
Vietnam (IRRI)	9	4.1	12	5.8
Sri Lanka (Dept. of Agric.)	32	5.3	24	5.7
Thailand (Dept. of Agric)	80	3.7	80	4.4

[a] n.a. = not available

yields is indicated by the datashowing 1 to 1.5 t/ha lower maximum yields under wet season conditions than under dry season.

Rice environment of Asia

Despite the often repeated statement that the new rice varieties *require* good irrigation, they are grown on substantial acreage of nonirrigated land. By 1974–75 in the Philippines, over 50% of the rainfed rice area had been planted to modern varieties, although adoption of the varieties in rainfed areas occurred somewhat later than in irrigated areas and yields were somewhat lower (Herdt and Wickham 1975). Very little of the upland area (nonflooded) was planted to modern rice varieties.

The difference between wet and dry season production has been stressed in the above discussion of maximum yields, but other environmental conditions are also important. Five significantly different, major rice environments have been distinguished: dry season, irrigated wet season, rainfed, deepwater, and upland. (The last two are later grouped together because their yields are similar,) Estimates of the extent of area for each type of environment have been made by examining available data and by conferring with knowledgeable rice workers. The data are discussed elsewhere (Barker et al 1975).

As already indicated, the dry season yield potential is substantially higher than that of the wet season in most areas of Asia, simply because there is more sunshine. However, this higher yield potential can only be achieved under good irrigation conditions; in fact, almost all dry season rice is irrigated. (Maximum yields for dry season rice in various countries have been discussed above.)

Irrigated rice lands often get a major part of their wet season water from rainfall. Hazards of flooding are generally less than in rainfed areas, although some irrigated areas are subject to fairly deep water. Maximum wet season yields discussed above for various countries were, in fact, obtained under irrigated conditions because nearly all experiments on rice are conducted with irrigation.

In many rice-producing areas, water obtained by a combination of rainfall and semicontrolled flooding provides the moisture for rice production. Indeed, in many areas the amount, depth, and timing of water release is beyond the control of farmers. Drought and floods are common in such areas. Areas with uncontrolled water depths of 30 to 50 cm are referred to as rainfed areas. Their potential yields are somewhat lower than those of the irrigated areas in the wet season, but very little data about varieties exist to document how much lower. In the Philippines, maximum trial yields from rainfed areas averaged 95% of the trial yields from irrigated areas, but national average yields from rainfed areas averaged only 68% of the yields from irrigated areas (Herdt and Wickham 1975). For our purposes, we assume that maximum rainfed area yields are 75% as high as wet season yields from irrigated regions.

Deepwater rice is grown in areas where the water is expected to exceed 30 cm for a sustained period during the growing cycle. In some of the more extreme cases, water may may reach depths of 1 to 6 m, and floating rices are cultivated. Upland rice is grown on soil where water is not expected to accumulate and where no special efforts, such as puddling or channeling, are made to keep water in the fields. No modern rice varieties are available for deepwater or upland areas. Current actual yields of upland and deepwater rice types probably average 1 t/ha, but an international trial of promising upland varieties and lines averaged 2.4 t/ha at 25 locations throughout Asia. Using rough judgment, we assume 2.0 t/ha as the potential yield for the upland and deepwater areas.

Our best estimates of the percentage of rice in each of four environmental categories are shown in Table 7. An estimate of the percentage of the area that produces a second rice crop is also shown. The latter is taken as an estimate of the dry season irrigated crop because the main growing season is the wet season. The wet season irrigated area is then obtained by subtracting the dry season irrigated area from the total irrigated area. One exception to this general categorization is Pakistan. Although grown during the wet or kharif season, rice in Pakistan is grown under conditions very similar to those of dry season irrigation in other countries – low humidity and high solar radiation. Maximum wet season yields there correspond to the yields obtainable in the dry season in other countries.

India, Indonesia, the Philippines, Pakistan, Malaysia, and Sri Lanka all have 40% or more of their rice lands irrigated, but only Indonesia, Malaysia, and Sri Lanka have more than 15% of the geographic wet season area irrigated during the high-yield-potential dry season. Bang-

Table 7. Estimates of the proportion of rice area in 5 major environmental categories in 11 Asian countries, 1970 - 75.[a]

Country	Toial rlce area[b] (thousand ha)	Proportionof area (%)								
		Irrigated		Rainfed		Upland	Deepwater		Second crop	
India	1.6	0.48	1.43	0.38	1.20	5.9	4.6	2.0	3.5	4.1
Bangladesh	1.7	1.89	13.21	3.77	18.88	6.8	5.4	2.0	4.0	4.4
Indonesia	2.5	1.61	2.37	1.87	2.63	5.9	4.8	2.0	3.6	4.0
Thailand	1.9	0.14	0.63	0.63	5.63	4.4	3.7	2.0	2.5	2.7
Burma	1.7	0.98	0.59	4.39	3.81	6.6	4.9	2.0	3.7	3.3
Philippines	2.4	0.14	0.27	0.68	1.63	5.8	4.1	2.0	3.1	3.1
Vietnam[c]	2.5	0.15	0.22	0.01	0.22	5.7	5.3	2.0	4.0	4.8
Paktstan	1.7	0.05	0.80	0.10	4.04	6.0	4.8	2.0	3.6	3.8
Nepal	2.3	1.52	0	0	0	6.0	4.8	2.0	3.6	6.0
Malaysia (W)	1.9	0	0.19	0.11	0.91	6.0	4.8	2.0	3.6	3.7
Sri Lanka	2.5	0.27	0.27	0.02	0.15	6.0	4.8	2.0	3.6	4.5

[a]Source: Barker et al (1975) and as indicated in the text. [b]1970–74 average area. FAO data. [c]Former South Vietnam

ladesh and Vietnam, with a high percentage of rice land in deep water, and Nepal and Burma, with high proportions of land in the rainfed categories, have among the most unfavorable rice-producing environments.

Given the differences in maximum yields for different environments, the average maximum yield in any country is clearly affected by the proportion of its area in each environmental category. Table 8 shows the area in each of the four environmental categories, along with the actual yield, and the maximum potential yield weighted by the proportion of area in each environmental regime. Average maximum potential yields range from 3.1 t/ha in Vietnam to 6.0 t/ha in Pakistan. These levels are substantially below the dry season maximum of 6 tlha, but still well above the actual yields of 1.6 to 2.5 t/ha. Having been derived from experimental data, these estimates are relatively generous maximum possible national yields.

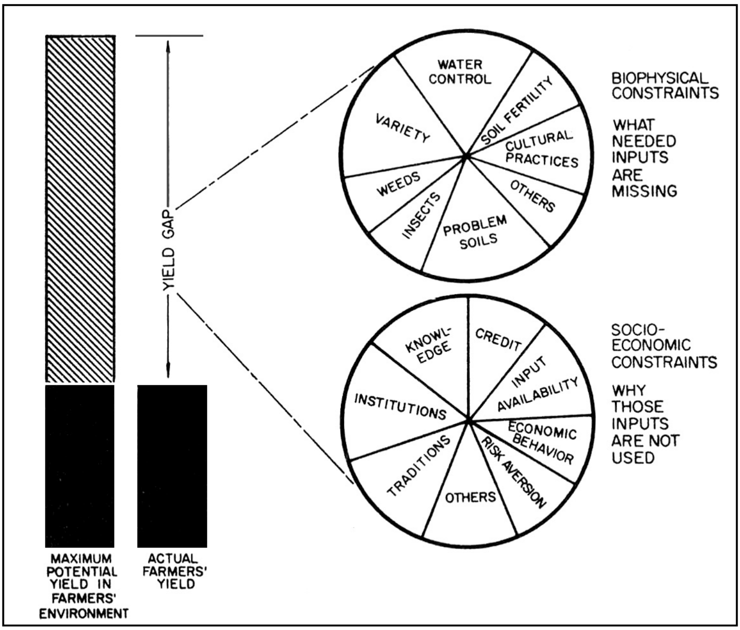
Why the yield gap exists

In trying to understand why the yield gap exists, we have concentrated our International Rice Research Institute (IRRI) research on yield gap II– the difference between the yield that is potentially attainable on farms and the present actual yield on the same farms (Fig. 3). This difference, which can be experimentally measured in farmer's fields, exists because farmers do not use all available technology to attain maximum yields. This is partly because it is not profitable for farmers to remove all biological constraints on maximum production. In other cases, farmers may not know how to use new technology, or technological inputs may not be

Table 8. Estimated weighted average maximum potential yield bared on area planted to 4 major types of rice[a] and country-specific maximum yields, 11 countries of South and Southeast Asia.

Country	Actual yield (t/ha)	Area (million ha)[b]				Maximum potential yield (t/ha)[c]				
		DS	WS	UD	RF	DS	WS	UD	RF	Weighted average
Philippines	1.6	0.48	1.43	0.38	1.20	5.9	4.6	2.0	3.5	4.1
India	1.7	1.89	13.21	3.77	18.88	6.8	5.4	2.0	4.0	4.4
Indonesia	2.5	1.61	2.37	1.87	2.63	5.9	4.8	2.0	3.6	4.0
Thailand	1.9	0.14	0.63	0.63	5.63	4.4	3.7	2.0	2.5	2.7
Bangladesh	1.7	0.98	0.59	4.39	3.81	6.6	4.9	2.0	3.7	3.3
Vietnam[d]	2.4	0.74	0.27	0.68	1.63	5.8	4.1	2.0	3.1	3.1
Sri Lanka	2.5	0.15	0.22	0.01	0.22	5.7	5.3	2.0	4.0	4.8
Burma	1.7	0.05	0.80	0.10	4.04	6.0	4.8	2.0	3.6	3.8
Pakistan	2.3	1.52	0	0	0	6.0	4.8	2.0	3.6	6.0
Nepal	1.9	0	0.19	0.11	0.91	6.0	4.8	2.0	3.6	3.7
Malaysia	2.5	0.27	0.27	0.02	0.15	6.0	4.8	2.0	3.6	4.5

[a] DS = dry season, WS = irrigated wet season, UD = upland and deepwater, RF = rainfed. [b]Based on IRRI estimates of proportton in various types (Palacpac 1976) and 1970–74 total area planted to rice as reported by FAO. [c]Average maximum potential yields obtained as discussed in the text for Philippines, India, Indonesia. Thailand, Bangladesh, Vietnam, and Sri Lanka. For other countries, maximum possible yields were taken as the average of the above countries. [d]Former South Vietnam.



3. The “yield gap” between potential and actual farmers’ yields is due to both biophysical and socioeconomic constraints.

available, or there may be other explanations for yield gap II. To include all these possibilities, we refer to the causes of yield gap II as socioeconomic constraints. If we can understand gap II for a sample of farms, we believe it will be possible to break through some of the constraints.

To get better information with which to understand yield constraints, IRRI began, in 1974, a series of farm-level studies of yield gap II (Appendix A). The studies are a cooperative project among the IRRI Agronomy, Statistics, and Agricultural Economics Departments and include agronomic field trials as well as farm surveys. The major objectives of the project are:

1. to measure, in farmers' fields, the actual yield achieved by the farmer and the maximum yield attainable by applying the three or four most critical inputs needed to raise yields – i.e., to measure gap II;
2. to determine the contribution of each of the three or four most important inputs to closing yield gap II;
3. to estimate the maximum possible benefits from the inputs being evaluated; and
4. to determine why some farmers do not apply inputs at the maximum level of benefit.

After the research methodology had been developed and tested at IRRI, other rice researchers in the region undertook similar studies. To date, there are two teams working in Indonesia and one each in Thailand, Sri Lanka, Taiwan, and Bangladesh.

An illustration of the type of information being obtained for the Philippines by this research is provided in Table 9. Experiments were conducted in farmers' fields in two provinces to compare farmers' use of three inputs with the level, time, and method of using the same three inputs that the agronomists believed would produce maximum yield. In the dry season, yields were between 1.6 and 2.5 t/ha lower with farmers' level and method of input use than with the high levels of fertilizer, weed control, and insect control (the sum of "measured yield gap" for each factor). Fertilizer was the major factor contributing to lessening the yield gap, with insect control being of moderate importance. In the wet season, the yield gap in Nueva Ecija was substantially smaller than during the dry season. Insect control caused a larger proportion of the yield gap in the wet season than in the dry, and fertilizer a somewhat smaller proportion.

Reasons why farmers did not apply a high level of inputs were identified for each farm on which an experiment was conducted (Table 9). The 1 t/ha yield gap attributed to fertilizer in Laguna was traced to inefficient use of nitrogen by farmers, who applied approximately the optimum amounts but apparently did not do so at the right time or use the correct techniques. A high level of insect protection was not profitable on half of

Table 9. Proportion of the measured yield gap from higher-than-farmers' levels of fertilizer, weed control and Insect control that is attributed to each socioeconomic constraint. Philippines, 1976.

			Measured yield gap (%) due to constraints				
Yield gap source	Measured yield gap (t/ha)	Farms (%) with no gap	Not profitable enough[a]	Used high inputs inefficiently	Thought input level was adequate	Reported lack of capital	Others
			Laguna, dry season				
Fertilizer	1.0	11	0	47	8	0	45[b]
Insect control	0.6	10	48	0	52	0	0
Weed control	0.2	0	18	65[c]	16	0	0
			Laguna, wet season				
Fertilizer	0.7	22	0	51	0	3	46[d]
Insect control	1.6	7	45	0	32	0	23
Weed control	0.2	20	4	0	64	5	0
			Nueva Ecija, dry season				
Fertilizer	1.4	0	8	0	61	31	0
Insect control	0.8	22	26	0	74	0	0
Weed control	0.3	11	4	0	75	0	21
			Nueva Ecija, wet season				
Fertilizer	0.6	0	40	13	11	11	25
Insect control	0.9	0	10		22	11	57[e]
Weed control	0.0	67	61	0	39	0	0

[a]The marginal benefit:cost ratio was below 2.0. [b]On fields of farmers who feared Insect attack, lodging, or lack of water. [c]These farmers used high levels of weed control, mainy through *gama*, a system whereby weeding and harvesting are contracted for a share of the crop. *Gama* was also used in the wet season, but the researchers used higher cost herbicides that season. [d]Mainly contributed by one farm where a nonresistant variety was grown with inadequate level of insect protection [e]Forty-six percent thought resistant varieties did not require protection from tungro, while protection was used in the experiment.

the Laguna farms. On most of the other Laguna farms, higher insect protection levels would have increased profits, but farmers thought they had applied enough insecticide. Some Nueva Ecija farmers lacked capital to use more inputs, but this was not a widespread problem. More commonly, farmers thought their use of inputs was adequate to get high yields, especially in the dry season. In the wet season, high levels of fertilizer produced no more yield than that obtained by other farmers in Nueva Ecija.

This kind of information, developed by carefully evaluating recommended technology under farmers' conditions, can provide feedback to three groups of decision makers who significantly affect agricultural growth: agricultural researchers, extension officials, and policy makers.

The finding that high levels of insect protection give a substantial yield increase, but not a profitable one, indicates the need for research on more efficient methods of insect protection. Since this finding was first made several years ago, entomologists and other researchers have been working to develop cheaper, more effective insect-protection techniques. Reducing the rates and optimizing use with a liquid insecticide injector are some approaches that appear promising.

Where research reveals farmers' lack of knowledge or inefficiency, extension workers may be the means for correcting that. For example, extension workers should take advantage of the Laguna farmers' willingness to invest in fertilizer by providing them with information on how best to use it. The information should be welcomed by the farmers because it would improve their profits without additional costs.

Policy makers can affect the relative profitability of input use through the price policies they impose. They can also determine the availability of institutional credit and the terms under which it is made available to the farmers. The data developed in the study showed that credit problems increased in importance between 1974 and 1976.

CONCLUSION

Since the 1950s, rice production in most countries of the region has just kept pace with increases in demand. Where that was not achieved, imports increased (Bangladesh), or exports decreased (Nepal, Burma). Expansion of cultivated area provided much of the increase in production during the 1950s, while yield increases per unit area dominated the later period.

A decade ago, most countries in the region were just beginning to intensify their use of fertilizer and other modern inputs. The advent of the modern varieties of grains greatly increased rice production, but it now appears that the new varieties and the modern inputs to existing suitable environments have achieved most of what they can. In the absence of new land areas fit for rice production, there are now three ways for expanding output in the decade ahead:

1. To close the gap between potential farm yield and actual farm yields through the improvement of extension systems, credit, and input distribution, etc.;
2. To expand and improve the irrigation systems so that an increasing proportion of the cultivators can take advantage of the existing modern seed-fertilizer technology; and
3. To develop varieties of rice that are both fertilizer-responsive and better adapted to the less favorable soil and water environments of Asia.

In the past few years, IRRI and many other groups have been working on the latter alternative. As yet, however, new varieties and technology that substantially raise the yield potential in regions with poorer water control have not been developed. There appear to be limited prospects for breakthroughs in this area in the near future.

To maintain output growth in the decade ahead is going to be more difficult and more costly than in the past decade. The potential rate of growth in rice production now depends principally on the rate of development of water control – irrigation and drainage. There is a growing recognition of the importance of irrigation in many of the developing countries, but surprisingly, there is little interest on the part of either national governments or international lending agencies in developing ways to minimize the cost of irrigation or to improve the operating efficiency of existing irrigation systems to increase food production.

In summary, the increased growth of Asian rice and food grain production is becoming increasingly dependent upon the use of modern inputs and the development of irrigation. In the last decade, significant yield gains were achieved through the introduction of modern varieties and fertilizer, but much of their potential seems to have been fully exploited. As we look to the decade ahead, more research will be needed to provide answers to critical questions regarding the further expansion of modern technology and development of water control. If we cannot improve the efficiency with which irrigation and modern inputs are developed and used, we will almost certainly witness a slowing of the growth rate of production and a rise in the cost of food grains.

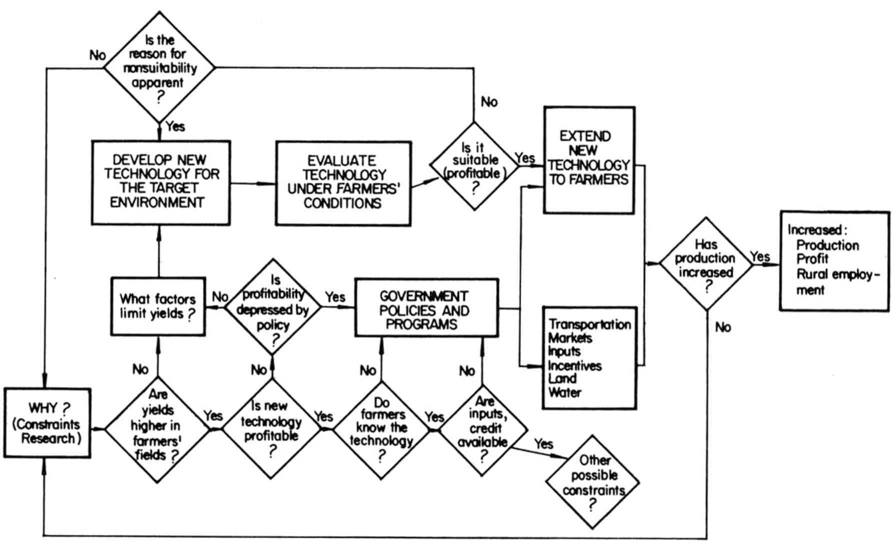
APPENDIX A. A NOTE ON THE YIELD CONSTRAINTS RESEARCH PROJECT[1]

The goal of agricultural development (extreme right of Fig. 1) is to increase production, profit, and rural employment. Attaining this goal will require that new technology appropriate to the environment be extended to farmers, together with the inputs of land, water and sunlight, and other inputs delivered through a marketing system that will also provide an opportunity for profitable sales of the food produced.

The broad objective of research at IRRI is to develop new technology potentially able to increase profitably both rice and other food production from rice-based cropping systems. Thus, research is only one component of the agricultural development process.

If production does not increase, or does not increase at an appropriate rate, one may examine the possible reasons through the approach developed in the Constraints Project. (This project focuses on rice yields, but many of the principles can be used in other contexts.)

Figure 1 illustrates the set of questions being asked in the Constraints Project:



1. The constraints research process.

[1]IRRI's Yield Constraints Project is a joint project of the Agronomy, Statistics, and Agricultural Economics Departments of the Institute.

1. Are producers' yields increased by actually using the newly developed technology in farmers' fields? If not, what factors restrict yields? (Feedback to research)

2. Is the new technology more profitable than the technology already being used by farmers?

3. Is the level of profit restricted by government policies; if so, can those policies be changed, or can the technology be redesigned? (Feedback to policy makers, research)

4. Do farmers have adequate knowledge to use the technology effectively? Are the necessary inputs and credit that may be required to use the technology available to farmers? If not, how must programs be changed to ensure this availability?

To the extent possible, IRRI's Yield Constraints Project seeks:

1. To quantify the difference between actual yield of rice and the potential yield attainable by adding the three or four most critical factors needed for high yields but which farmers are not using;

2. To determine the contribution of each of the three or four biological inputs to the yield gap;

3. To determine the maximum profit level of the inputs being tested;

4. To explain why farmers are not applying inputs at the maximum profit level, if indeed they are not.

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COMMENTS ON

Sources of growth in Asian food production and an approach to identification of constraining factors

JOSE D. DRILON, JR.

In his presentation, Dr. Herdt made it clear that he had four objectives in mind: 1) to define food availability in Asia; 2) to give an indication of the rates of increase in cereal production; 3) to enumerate the reasons for increased output, particularly of cereal, in the region; and 4) to evaluate the possibility of further increases. I would like to make the following points:

1. The figures on food availability given by Dr. Herdt, and also by Dr. Chong, raise certain questions concerning accuracy. References were made to increases in food production and rates of increase in irrigation, water control, etc. But the actual figures for food production in Southeast Asia have to be treated with some caution because the criteria used to define production vary from place to place and from country to country. The same is true for data on food availability and food consumption.

No clear definition was ever given of what *food* is. In the latter part of his discussion, Dr. Herdt concentrated on the staple food cereals, creating the impression that the food problem is more of caloric than protein deficiency. There was no mention of protein-rich foods or protective foods, such as vegetables, which are rich sources of vitamins and minerals.

2. Despite the Green Revolution and the development of new technology, particularly technology for increasing the production of rice and wheat, the rate of food production in Asia in terms of the provision of 2,000 calories per day per person has just about kept up with population growth. But the region needs to do more than just providing calories; it should promote the production of a variety of food crops that are good sources of protein, vitamins, and minerals, and could also increase the caloric intake.

3. Dr. Herdt stated that in the region there has been a decline in the importance of newly cultivated land. The percentage of increased rice output attributable to the expansion of cultivated area dropped from 1.3%/year between 1955 and 1965 to 0.9% from 1965 to 1973. He said that even this understates the reality because the information on land area devoted to food crops is probably overstated, and, therefore, the situation is worse than it appears to be. He also pointed out that the constraints of available arable land do not appear to have affected wheat or maize production. I do not have an exact figure for wheat production, but for maize it is likely that availability of land would not be a limiting factor. This is illustrated by the story of the farmer who fell down on his farm and broke his neck. Someone asked, “Why did he break his neck?” The an-

swer was that a maize farm could include even hillside fields. This would explain Dr. Herdt's statement about the difference in land constraints upon the growing of maize and rice.

4. Maize is an important crop in India, Indonesia, the Philippines, and Thailand. Production of maize has increased significantly, particularly in Thailand over the past 15 or more years. One might recall that during this period, Thai maize exports went up to 1.8 and even 2 million t/year. Maize competes with tapioca, and even rice, in terms of export volume, and one of the principal reasons for this is the availability of a lucrative market. With such an encouraging market for maize, the Government did not have to exert extraordinary efforts to increase maize production in Thailand.

5. Regarding the reasons for increased production, Dr. Herdt indicated that irrigation, fertilizer, and different plant varieties would account for some 80% of the increase. This is a fairly accurate arithmetic evaluation of the contributions of these inputs to increased productivity, but I wonder how effective and dependable the methodology involved in such assessments is. The effects of combining irrigation, fertilizer, new varieties of plants, and better agricultural practices are synergistic. It should further be noted that the definition of what constitutes irrigated *land* is not consistent. In the Philippines, for instance, it is often said that there are slightly more than 1 million ha of irrigated land, but the latest information I have indicates that only 30 to 40% of this is actually irrigated in the technical sense to grow 2 crops annually.

6. I have six subpoints concerning the potential of food production in Asia, particularly with respect to rice.

a. Irrigation, drainage, and all of the agricultural inputs associated with improved technology, such as fertilizers and plant varieties, really stand out as the most significant factors for increasing food production in Asia. If this is so, how much would it take to increase food production significantly through better water control? Recently, we came across the estimate that about US$3,000/ha can make a farm completely technically irrigated. Thus, to increase rice production in Asia, a major part of planning should be a financial program that would enable countries to undertake irrigation projects. In this regard, cost-benefit ratios may have to be set aside as a concept used to justify irrigation projects. This is a radical suggestion, but it seems to be dictated by the situation. In the past 15 or more years of IRRI's existence, with all that it has done, and with everything governments in the region have attempted to do, rice production has just kept up with population growth. There are already signs that international funding agencies would probably set aside, or at least modify, the concept of cost-benefit ratios to aggressively open up new lands *vertically*, so to speak, through more irrigation projects. I say "vertically" because horizontally, as Dr. Herdt pointed out, the arable land frontier is fast closing on us, except perhaps in Malaysia.

b. It is obvious that the dry season crop has a greater yield potential than the wet season crop offers, and again, this points to the importance of having technically complete irrigation projects. Increased irrigation will enable us to have more dry season crops.

c. Dr. Herdt reported that only 17-50% of the rice agricultural technology now available is being used in Asia, yet in this technology lies a large potential for fighting hunger in Asia. We must find out what means should be employed and what can feasibly be done to optimize the use of this technology. However, the generation of still newer relevant technology through research should be encouraged and continued, as it can offer greater opportunities for increasing yields. An example is the introduction of new rice-growing technology in Korea in 1971 which, as mentioned by Dr. Herdt, brought new yield increases in that country.

d. Perhaps the “yield” concept should also include the ready-to-use commodity concept, because postharvest conservation technology offers great promise of increasing food availability, even without an increase in yields at any one time. A 30% increase in food supplies is possible by reducing postharvest losses. The SEARCA-based postharvest technology program is making a major effort to confront this problem.

e. When we talk about infusing technology into farming, we must remember that we are talking, in most cases, about small farms whose size carries many implications relative to their ability to continue, on a sustained basis, the use of productive technology. A small farmer has only limited capacity to absorb losses. He accumulates capital slowly and requires financial assistance from outside–from his government, or from financial institutions in his locality. He needs credit to enable him to purchase the inputs of technology and to use the most productive technology available to him.

However, it is well established that the small farmer, being human, develops a liking for consumer goods. If, in the beginning, he is helped with credit to enable him to raise his productivity, very soon the monetary fruits of such productivity become insufficient for the newfound purchasing power of credit. At first he may be quite efficient in repaying his credit debts, but after a while he realizes that credit, which leads to increased production, indirectly provides him with more money to buy consumer goods more easily. There is a danger that instead of investing at least some of his money in his farm, he may spend it all on goods and his total income will be suppressed by his small farm’s limited productivity. Once this happens, he falls into debt again, as he was in the years before he adopted the new technology. Thus, he may enter a cycle wherein he cannot continue to use the new technologies, or, even if he can, he must still look for other sources of income to enable him to cope with his increased propensity to consume.

f. The final question is: What is the best strategy for the farmer to become an effective instrument for helping to solve the food problem? There are a number of issues that should be mentioned, such as whether we should concentrate on redesigning technology, or on government policies and programs, or on a combination of the two. Given the limitations of the small farms, there is the question of whether it would be wise to concentrate on increasing rice yields only, or to consider multiple cropping, or to promote the development of small- and medium-scale industries to augment the income of farmers and the landless poor, who together constitute 60-70% of the rural population. Of course, there are subsidiary questions that may be asked. Whenever alternatives are available, in the ultimate analysis, from the standpoint of those who have to make the decisions — policy decisions at the government level, or even tactical decisions at the level of the farmer — there is always the question of what choice or combination of choices will prove most effective.

Discussion

Although the protein content of brown rice was not monitored in the Constraints Project, previous studies at IRRI have shown that increased yield as a result of the use of nitrogen fertilizer has a quadratic relationship with grain protein content. Both yield and protein content can be increased simultaneously only up to a point; beyond it, an increase in protein content can be obtained only with a decrease in grain yield. In addition, the protein content of high yielding varieties is comparable to that of the traditional varieties that they replace in the farmers' fields in parts of the Philippines and Thailand.

Dr. Herdt stressed that projections of population, population increase, area, and yield potential are conditional. World Bank investments in irrigation and prices of imported rice are correlated. Sharp annual changes in the rice production cost-benefit ratio result in rapid responses by decision makers. When the cost-benefit ratio is good, the World Bank asks for investment in irrigation.

Only 30% of the area studied in the Constraints Project is planted to high yielding rice varieties, representing lowland irrigated areas. IRRI is now involved as collaborator in, and coordinator of, research to develop high yielding rices that are adapted to deep water, drought, toxic and problem soils, and low temperature; and are resistant to insect pests and diseases, and related problems that reduce rice yields.

The status of food science and the potential for food processing in Thailand

AMARA BHUMIRATANA

THE ECONOMY OF A COUNTRY and the nutritional status of its people are inevitably interdependent. If a country is beset with economic difficulties, a large proportion of its population will be undernourished and, consequently, susceptible to disease and unable to work efficiently. Under these circumstances, malnutrition affects not only the health and well-being of the people, but also the economy of the nation as a whole.

Shortage of food, if indeed there is such a shortage, may not be the main cause of a nation's malnutrition. Inequitable food distribution, insufficient food intake, and poor dietary habits all contribute, in varying degrees, to the problem. Loss of food crops to pests, diseases, and improper handling and processing also add greatly to food problems. For example, it is estimated that some Asian countries lose 18% of their total annual food crops to pests and diseases alone. Thus, coordination among agriculturists, nutritionists, and food scientists is needed to combat malnutrition. The description that follows is drawn from Thailand, but it could apply equally to other developing countries in Asia.

THE PROBLEM

The malnutrition that exists in Thailand includes several nutritional deficiency diseases. The major ones are protein-calorie malnutrition, vitamin A deficiency, deficiencies in vitamins B_1 and B_2, simple goiter, iron deficiency anemia, and bladder stones. Of these, protein-calorie malnutrition is the most widespread and is severe among infants over 6 months of age, through the preschool years, and among pregnant and lactating women.

Although the problems of malnutrition are complex, they can be tentatively broken down into six groups, as follows:

1. The incidence of malnutrition is greatest and most severe among preschool children between 6 months and 5 years of age. Fifty-two to

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76% of the children of low-income families in the slum areas of Bangkok and in the rural areas suffer some degree of malnutrition.

2. The number of deaths among children 4 years old and younger is as high as 22.5% of the total deaths for all age groups. It is estimated that over 100,000 Thai children in this age group die each year, and of these, about 55,000 die of malnutrition and associated causes.

3. Although few school children die of malnutrition, continued retardation of physical growth and an impaired capacity for learning and physical work occur in children of this age group in lower-income families. Surveys indicate that about 30% of the school children in poor rural areas and in the Bangkok slums show signs of nutritional deficiencies. Their physical growth is markedly retarded, compared with that of children in middle-income families in Bangkok.

4. Protein malnutrition exists among pregnant and lactating women because they do not receive extra food during pregnancy or lactation. The number of deaths caused by complications of pregnancy and delivery is high — about 81% of all deaths among women of reproductive age. Poor prenatal maternal nutrition is also reflected in infants of low birth weight: rural newborns of 2.5 to 2.6 kg or less, compared with infants of 3.0 kg or more for middle-income families in Bangkok.

5. It is recognized that physical work requires an adequate diet, especially foods that provide energy and protein. Studies of physical laborers show that the average intake of essential nutrients is less than recommended allowances, and deficiency diseases are common among laborers and farm workers.

6. Average life expectancy in Thailand—55 years for males and 65 for females — is still low compared to the average life expectancy of 70 in the developed countries of Asia. The high death rates of infants and young children are mainly responsible for this low life expectancy. The population distribution, mortality figures, life expectancy, and total GNP (Gross National Product) for Asian countries are shown in Table 1.

CAUSES OF THE PROBLEM[1]

To solve the problem of malnutrition in Thailand, the major causes of undernutrition must be identified and we will do so in what follows, although it is generally agreed that no one factor is, by itself, *the* cause.

Population growth and food production

Malnutrition will occur if food production falls behind population growth. Comparison of food balance sheets for 1966 and 1972 indicates almost

[1]The major part of the analysis in this section was taken from the fourth National Economic Social and Development Plan, which was prepared by the National Economic and Social Development Board of Thailand.

Table 1. Population distribution, mortality figures, life expectancy, and total per capita GNP (US$) in Asian countries.[a]

Country	Population (million)	Birth rate (per thousand per year)	Death rate (per thousand per year)	Population growth rate (%/year)	Years (no.) until population doubles	Forecast to 2000 A.D. (million)[b]	Infant mortality	% > 15 yr	Average life expectancy (years)	Per capita GNP[c] (US$)
Australia	13.8	21.0	8.1	1.9	36	20	17	28	72	2980
Bangladesh	73.7	49.5	28.1	1.7	41	144	(132)	46	36	70
Bhutan	1.2	43.6	20.5	2.3	30	2	—	42	44	80
Burma	31.2	39.5	15.8	2.4	29	55	(126)	41	50	90
Cambodia	8.1	46.7	19.0	2.8	25	16	127	45	45	120
China	822.8	26.9	10.3	1.7	41	1126	(55)	33	62	160
Hongkong	4.2	19.4	5.5	1.4	50	6	17	32	70	980
India	613.2	39.9	15.7	2.4	29	1059	139	42	50	110
Indonesia	136.0	42.9	16.9	2.6	27	237	125	44	18	90
Japan	111.1	19.2	6.6	1.3	53	133	12	24	73	2320
North Korea	15.9	35.7	9.4	2.6	27	28	—	42	61	310
South Korea	33.9	28.7	8.8	2.0	35	52	(60)	37	61	310
Laos	3.3	44.6	22.8	2.2	32	6	(123)	42	40	130
Malaysia	12.1	38.7	9.9	2.9	24	22	(75)	44	59	430
Mongolia	1.4	38.8	9.4	3.4	23	3	—	44	61	380
Nepal	12.6	42.9	20.3	2.2	32	23	(169)	42	44	80
New Zealand	3.0	22.3	8.3	1.4	50	4	16	30	72	2560
Pakistan	70.6	47.4	16.5	3.1	22	150	(132)	46	50	130
Papua, New Guinea	2.7	40.6	17.1	2.4	29	5	(159)	42	48	290
Philippines	44.1	43.8	10.5	3.3	21	90	(78)	46	58	1300
Singapore	2.2	21.2	5.2	1.6	43	3	20	33	70	110
Sri Lanka	14.0	28.6	6.4	2.2	32	21	45	39	68	490
Taiwan	16.0	(24.0)	(5.0)	1.9	36	22	(28)	(39)	(69)	220
Thailand	42.1	43.4	10.8	3.3	21	86	(65)	46	58	110
Timor	0.7	44.3	23.0	2.1	33	1	(184)	42	40	100
Vietnam	44.0	41.5	20.7	2.1	33	38	—	41	44	170

[a]Taken from 1976 Asia yearbook. [b]U.N. Population Division estimate. [c]Gross national product.

Table 2. Projected population figures for Thailand.

Year	Population
1977	44,882,000
1978	46,199,000
1979	47,530,000
1980	48,868,000
1981	50,222,000

no increase in food supplies for domestic consumption during this period, although aggregate balance and average per capita data imply enough food to meet the average daily demand of each person for 1,920 calories, 38 g protein, and 300 to 400 g of rice. There was, however, a marked increase in population during those years: from 31,955,000 in 1966 to 38,577,000 in 1972, or an increase of 3.1-3.2%/year, based on medium fertility estimates. Thus, during this period, the population grew by about 7 million, while the increase in food supply was almost negligible. The population increase is expected to continue over the next few years, as shown in Table 2.

Family income

Diet is closely related to family income. Income determines expenditure for food in middle- and low-income families, but a family's diet is not automatically better with higher income, although consumption of meat and milk products, fruits, and vegetables increases eventually as income improves. There are instances, however, when higher income leads to the substitution of processed foods and "prestige" foods for the subsistence diet, thereby worsening the nutritional status of the family.

Families in both urban and rural areas spend an average of 48% of their income per month for food, but this conceals the fact that families with a very low income often spend 90% or more on food. Family income usually derives from two sources – visible and invisible. The visible income includes salary, wages, and net profit from business, while the invisible income cannot be calculated by monetary value and usually forms a larger part of the rural economy than of the urban. Data show that the average invisible income for the whole population is 38% of the total visible income for the rural population and 5% for the urban. It is 76% in northeast Thailand, 46% in the north, and 15% in central Thailand.

For problem analyses, the two sources have been combined and compared with the least-cost expenditure on foods the family needs to meet minimum requirements. Formulas of a least-cost diet for a family of six have been prepared, based on the quantity of food needed by the family, its nutritive values, and its cost. Application of that estimate reveals that 61% of all families in rural Thailand do not spend enough income on food to have an adequate diet. At least 3% of the urban families are also in this category.

In reviewing the relationship of income to nutrition, it is important to recognize that family income adequate to produce or purchase sufficient food to assure satisfactory nutritional status for all family members does not assure that each individual will be properly fed. Distribution practices within the family often lead to malnutrition among young children, even in higher-income groups.

The regional distribution of families who cannot afford enough food to fulfill minimum requirements is as follows: whole country, 64.1%; north-east, 77.2%; north, 71.1%; south, 71.9%; and central, 53.9%.

Eating habits and patterns

People's eating patterns usually vary according to the community's ecology as well as tradition. The urban community has patterns and habits of eating that are different from those in the rural area. Family income and the mother's nutritional knowledge also determine the quality of food prepared. Generally, a Thai meal consists of cooked rice consumed with *kaeng* or *nam prick,* vegetables, and a small amount of protein food such as fish, meat, or egg. The protein food is usually considered an appetizer rather than, the main item of the diet. This type of meal is low in fat.

In the rural areas, traditional beliefs and food taboos that contribute to poor eating habits are widespread, especially among pregnant and lactating women. For example, pregnant women are not allowed to eat meat or eggs, and certain foods are prohibited after delivery.

Food distribution

In several areas in Thailand, especially in the northeast, lands are arid and poor, and crop yields are insufficient even to provide food for home consumption. The remoteness and isolation of the areas mean that food is poorly distributed, or fails to arrive at all. Malnutrition is common in the region.

The food marketing and distribution system also leads to nutritional gaps. Foods frequently do not reach consumers at costs they can afford. Rice shortages, for instance, have occurred almost every year in spite of the aggregate surplus that appears in the statistics. The same problems affect other food commodities, particularly protein foods whose frequent shortage and higher prices cause hardship among the low-income sectors of the population. The following factors are involved:

1. The policies for production and domestic consumption are not coordinated. Food processors are usually more interested in accruing profits, neglecting the nutritional needs of the consumers.
2. Hoarding by merchants causes food shortages and higher prices.

3. There is both legal and illegal overexportation of food commodities.

4. The inadequate marketing system results in too great a difference between production cost and retail price.

Importation of food commodities

The policy governing food imports does not relate to the nutritional needs of the population. Thailand allows merchants to import freely foods that are unnecessary for nutritional improvement. This wastes foreign currency, causes trade balance deficits, and contributes to poor nutritional habits.

Knowledge of proper use of foods

In several locations, foods are not fully utilized in spite of abundant supply because the people are neither aware of their nutritive value nor of the proper methods for preparing them. As a result, many Thais suffer from malnutrition even without food shortages or lack of buying capacity. The food taboos in the rural areas, mentioned earlier, are a further contributing factor to malnutrition, especially for pregnant and lactating women.

The feeding of infants and young children is another problem. Bangkok mothers substitute artificial formulas for breast milk. Hospital statistics in Bangkok reveal that 80% of the young children who are admitted to PCM (Protein-Calorie Malnutrition) wards have been fed with sweetened condensed milk. This change from breast-feeding is dangerous for infants and young children because sufficient intake of protein and other essential nutrients is not assured. Besides, the substitute is often contaminated during preparation, thus becoming a cause of diarrhea.

Infectious diseases

The nutritional status of infants and young children is worsened by infections such as diarrhea, measles, coryza, chicken pox, and whooping cough. The stress of infectious diseases increases the body's need for protein, and protein malnutrition often occurs unless protein loss is replaced during recuperation. If it is not, the next infection may lead to severe malnutrition and even death.

Infectious diseases associated with malnutrition account for the high death rates among children under 5 years of age. In 1974, 55,000 deaths were attributed to malnutrition and its interaction with infection.

Parasitic infestations are also responsible for malnutrition because the parasites compete with the host for essential nutrients and often deprive the host of them. Certain parasites, such as hookworms, cause bleeding and contribute to iron deficiency anemia. Interference with absorption occurs when the number of parasites is great enough to provoke mechanical blockage and inflammatory reactions in the intestinal mucosa. The highest prevalence of parasite infestation is in the northeast, where it affects 56.3% of the population, 36.9% of whom have liver fluke. Hookworm is commonly found in every region of the country; the highest prevalence, 46%, is in the south.

SOLUTIONS TO THE PROBLEM

It is clear that the causes of malnutrition are multiple and require coordination of efforts in many disciplines. Thus, at the national level, the National Social and Economic Development Board of Thailand has outlined the following policy for the fourth period of the National Social and Economic Development Plan, which will cover the 5 years from 1977 to 1981.

Food and nutrition policy objectives

1. Develop better public health measures for all segments of the population to lower the morbidity and mortality rates.
2. Increase human working capacity and productive years by improving the nutritional status of the population.
3. Develop programs within the health-care system that will prevent and rectify nutritional problems.
4. Assure an adequate food supply to meet the nutritional needs of all segments of the population by improving programs for the production of nutritious foods. These foods should be available to the consumer at reasonable cost.
5. Assure an adequate food supply for the nutritional benefit of domestic consumers by developing an appropriate system of distribution, transportation, storage, and marketing, and by better management of import and export policies for food commodities.
6. Develop, at all levels, a sound knowledge and understanding of foods and nutrition by strengthening programs for nutrition education, both in the school curriculum and for the general public.
7. Maintain a system of quality and safety control of food supplies by strengthening food-control measures, food sanitation, and personal hygiene services.
8. Raise the social and economic standards of all segments of the population, and assure the availability of food and good nutrition by promoting employment opportunities and other measures that will provide higher incomes for more people.
9. Support research and education in foods and nutrition with carefully planned priorities to solve important current problems and to permit basic research for future implementation.

To assist in formulating dietary goals, standards for daily Recom-

Table 3. Recommended daily dietary allowances to maintain good nutrition for the majority of the population of Thailand (allowances are intended for normally active persons).

Group	Age (year)	Wt (kg)	Calories	Protein (g)	Calcium (g)	Iron (mg)	Vitamin A value (IU)	Thiamine (mg)	Riboflavin (mg)	Niacin acid	Ascorbic acid (mg)	Vitamin D (IU)
Men	20–29	54	2550	54	0.5	6	2500	1.0	1.4	17	30	400
	30–39		2450	54	0.5	6	2500	1.0	1.4	16	30	400
	40–49		2350	54	0.5	6	2500	0.9	1.3	16	30	400
	50–59		2200	54	0.5	6	2500	0.9	1.2	14	30	400
	60–69		2000	54	0.5	6	2500	0.8	1.1	13	30	400
	70+		1750	54	0.5	6	2500	0.7	1.0	12	30	400
Women	20–29	47	1800	47	0.4	16	2500	0.7	1.0	12	30	400
	30–39		1700	47	0.4	16	2500	0.7	0.9	11	30	400
	40–49		1650	47	0.4	16	2500	0.7	0.9	11	30	400
	50–59		1550	47	0.4	6	2500	0.6	0.8	10	30	400
	60–69		1450	47	0.4	6	2500	0.6	0.8	10	30	400
	70+		1250	47	0.4	6	2500	0.5	0.7	8	30	400
Pregnant women[a]			+200	+20	1.0	26	2500	0.8	1.1	13	50	400
Lactating women			+1000	+40	1.2	26	4000	1.1	1.5	18	50	400
Infants	0–1	6	Kgx100	14	0.5	Kgx1	1000	0.3	0.4	4	20	400
Children	1–3	10	1200	17	0.4	4	850	0.5	0.7	8	20	400
	4–6	16	1550	21	0.4	4	1000	0.6	0.8	10	20	400
	7–9	20	1900	24	0.5	4	1350	0.8	1.0	12	30	400
	10–12	25	2300	32	0.6	8	1900	0.9	1.3	15	30	400
Boys	13–15	36	2800	40	0.7	11	2400	1.1	1.5	18	30	400
	16–19	50	3300	45	0.6	11	2500	1.3	1.8	22	30	400
		38	2355	38	0.6	16	2400	0.9	1.3	16	30	400
Girls	16–19	46	2200	37	0.5	16	2500	0.9	1.2	14	30	400

[a]Third trimester.

Table 4. Projected Thai demand for food per year.

Food	Projected demand for food (in thousand units)[a]		
	1975 (42.3 million)	1985 (55.7 million)	2000 (76.6 million)
Rice (t)	5,247	6,977	9,781
Paddy (t)	7,831	10,413	14,600
Whole fish (t)[b]	397	523	719
Eggs (units)	7,578,270	9,985,802	14,228,284
Chickens (units)	610,067	804,197	1,104,937
Pigs (units)	5,070	6,684	9,582
Cattle (units)	2,743	3,616	5,279
Peanuts (t)	231	305	419
Vegetables (t)	4,166	5,492	7,546
Fruits (t)	2,315	3,051	4,192
Fat (t)	463	651	922

[a] Figures in parentheses are population estimates for the given year. [b] Fish (100g) supplies the protein of 95 g of chicken, 90 g of meat, 150 g of eggs, 129 g of pork, and 82 g of pulses.

mended Dietary Allowances shown in Table 3 were prepared for Thailand. To fulfill these requirements, a projected demand for food supplies in Thailand was estimated for the years 1975-2000, assuming a population increase of more than 33 million by the year 2000 (Table 4).

CONTRIBUTIONS OF FOOD SCIENTISTS TOWARD SOLVING THE MALNUTRITION PROBLEM

The following section briefly discusses some of the food science and technology applied to solve problems of malnutrition in Thailand. Other disciplines, e.g., agriculture, family planning, socioeconomics, and public health, which can contribute to the solution, are beyond the scope of this discussion. The activities that food scientists and technologists have undertaken to combat malnutrition can be divided largely into two categories: 1) research, pilot plants, and small-scale industries; 2) industrial-scale production of IFRPD (Institute of Food Research and Product Development) products.

Research, pilot plants, and small-scale industries

Numerous institutes and universities in Thailand have trained students in the field of food science and technology and other areas related to food. Most of these training centers also carry on research – both in the laboratory and in pilot projects – that relates to food and nutrition.

Production of high-protein foods. The IFRPD has experimented with and developed many high-protein foods from raw materials that are available locally. These high-protein foods are produced by extracting

Table 5. IFRPD (Institute of Food Research and Product Development) products.

Product name	Components	Present average yearly production
Kaset Protein	Mung bean, soybean, vitamins, flavoring fish protein concentrate	14,000 kg
Baby Food	Rice flour (70.5%), full-fat soy flour (12.5%), sugar (16%), vitamins (1%)	110 t
Soybean Milk	Whole soybeans, cane sugar, lime water (before evaporation), soybean oil, methionine	90,000 cans
Full-fat Soy Flour	Ground whole soybean	—
Kanom Ping Kaset (soy protein cookies)	Wheat flour, full-fat soy flour, eggs, margarine, sugar, salt	65 t
Krob-Krob Kaset (extruded soy-rice mixture)	Full-fat soy flour, rice flour, vitamin-mineral premix, sugar flavorings	—
Kaset Noodles:		
Wheat	Wheat flour, defatted soy flour, methionine, lysine, flavorings	3,000 kg
Rice	Rice flour, full-fat soy flour, cassava flour, water	

protein from either soybeans or mung beans. More detailed information on these IFRPD products (listed in Table 5) can be obtained from the Institute of Food Research and Product Development, Kasetsart University, Bangkok, Thailand.

Distribution of IFRPD products. The listed IFRPD products are distributed through two main channels. Most of them are supplied to specific groups or programs in collaboration with other governmental organizations or private groups, such as child-care centers and school-lunch programs. A few products are introduced to the general public in a limited number of distribution centers.

1. Child-care centers. During the past several years, IFRPD products have reached 528 day-care centers located in many provinces around the country. Each center enrolls approximately 60 children. Thus, nutritious food has been fed to more than 30,000 children each day. Most child-care centers are operated by the Ministry of Public Health.

2. School-lunch programs. The IFRPD has also supplied school children with lunch for several years. This program resulted from collaborative efforts between the IFRPD and the Ministry of Education, Ministry of Public Health, and private volunteers. The major roles that IFRPD plays include:

a. acting as a central kitchen to distribute ready-cooked foods and provide necessary equipment to various schools in the program;
b. production of Kaset Protein for sale to schools under the school-lunch program;
c. training teachers or school officials participating in the program on the proper utilization of Kaset Protein.

3. General public. Due to limited marketing of IFRPD products, the amounts reaching the general population are relatively small.

Industrial-scale production of IFRPD products

After the successful pilot-scale production of the two IFRPD products Kaset Protein and Baby Food, the Government of Thailand has recently agreed, in principle, to build a full-size factory. The factory will have the capacity to produce approximately 2,000 t of Kaset Protein and 10,000 t of Baby Food per year.

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COMMENTS ON

The status of food science and the potential for food processing in Thailand

C. S. TSOU

As Professor Amara indicated, people are concerned not only about the quantity of food available, but also about its quality. One important feature of food quality is the variety of items for the diet, and the food-processing industry clearly has an important role here.

Food balance sheets do not provide an adequate picture because of such food distribution problems as differences in purchasing power, the seasonal nature of crops, and regional specificity of some foods, which necessitates their transport to other parts of the country. The processing industry can assist in more effective preservation and distribution of food already produced.

Early in February 1977, the Southeast Asian Regional Center for Graduate Study and Research in Agriculture (SEARCA) and the Asian Vegetable Research and Development Center (AVRDC) cosponsored a workshop in Los Baños, Philippines, on Pre- and Post-Harvest Technology of Vegetables. A survey was made of the participants, primarily agriculturists representing 10 countries, on their relative rating of the importance of the nutritional, production, and marketing problems encountered with vegetables. Nutrition was considered the least important. Although most of the participants did indicate that their countries had problems associated with deficiencies in protein, minerals, and vitamins, they did not assign much priority to food quality. Neither did the participants consider production to be top priority. From their standpoint, marketing and distribution were the most serious problems; in particular, 1) they felt the lack of adequate distribution and marketing systems within their countries, and 2) they cited seasonal fluctuations in supply of foods.

The food-processing industry should play an important role by canning or otherwise preserving foods immediately after harvest. A partial solution to distribution problems is to establish small, simple processing industries in the rural areas where the crops grow, both to preserve vegetables and to increase their shelf-life. Such industries could help make efficient use of perishable produce.

The contribution of food-processing technology should not be limited to the production of competitive, low-priced, high-protein products. Technology is capable of achieving far more, as shown by the food-processing industry in Taiwan. During the past 20 years, Taiwan's food processors have rapidly expanded the handling of pineapple, mushrooms, and asparagus. The processing of the three commodities succeeded as the result of a breakthrough in agronomic production technology and strong foreign market demand. None of these crops contributes significantly to nutrition in Taiwan because they are processed primarily for export. However, they have raised the incomes of small farmers and increased their purchasing power. This, in turn, helps improve food distribution. Here again, the complementary relationship between agriculture and the processing industry is evident.

Another important aspect of this relationship is the mutual assistance between processors and farmers, with the food-processing industry contributing mainly to food conservation and distribution. A contract scheme has been worked out in Taiwan whereby farmers assure the processors of a continuous supply of raw materials, the processors provide the farmers a guaranteed price and buyer, and the Farmers Association acts as an intermediary (e.g., collecting, grading, shipping, etc.) to ensure benefits to both parties.

Discussion

Pilot-plant production of Kaset Baby Food (soybean-rice) was initiated at the Institute of Food Research and Product Development, Kasetsart University, Bangkok. Because Kaset Baby Food is rice-based, it fits in well with the eating habits of Thais. Its ingredients are 99% indigenous and only 1% imported minerals and vitamins.

The involvement of industry in the commercial production of Kaset Baby Food has been beset with problems because of difficulties in the private and public sectors working together. The Government sector is in a better position to begin product development, but only the private sector can handle commercial production efficiently. The Government is reluctant to give the product it develops to industry.

The production of Incaparina in Guatemala experienced similar difficulties. Furthermore, it was hard to interest commercial companies in large-scale production of the relatively low-cost vegetable mixture based on cottonseed flour and corn. In the end, a local brewery set up a separate company to produce Incaparina in both uncooked and precooked forms and proved that it was a profitable investment. Present production, however, is only the equivalent of 20 million glasses of milk per month for a population of 55 million. The difficulties in linking product development by a government with commercial production by private industry are not unique to Southeast Asia.

The nutritional value of foods

CARMEN LL. INTENGAN

BEFORE A DISCUSSION of the nutritional value of foods, an explanation of how nutritionists make use of data on food composition is needed. In planning adequate diets for individuals, groups, or for a country as a whole, nutritionists are guided by a set of standards (usually called "recommended dietary allowances" or RDA) specific for a particular country. The nation's standard indicates the average amount of nutrients needed by various segments of the population according to age, sex, and physiological condition, such as pregnancy and lactation. These recommendations are generally estimated for a moderately active population. Adjustments will, therefore, have to be made to meet the needs of those who are sedentary, relatively active, and very active. The Food and Agriculture Organization (FAO) has recommended that these adjustments be –10%, +17%, and +34%, respectively, of the calories estimated for the moderately active adult (FAO Joint FAO/WHO Ad Hoc Expert Committee 1973). Calling these standards "recommended allowances" indicates that the amounts are tentative and subject to periodic revision. Table 1 gives the recommendations for calories and nine nutrients in the Philippines.

For practical use, it is necessary to translate the recommendations in Table 1 in terms of actual diets that can provide the proper amounts of the given nutrients. Therefore, data on the composition of foods, especially those indigenous to the country, are essential. The food consumption pattern of the people must also be taken into account. Table 2 shows the RDA specific for use in the Philippines. This table has been found to be of practical value, not only in the preparation and evaluation of individual dietaries, but also in the planning of the country's food supply.

The foods needed to meet the nutrient requirements recommended in Table 2 have been classified into three main headings: energy foods, body-building foods, and regulating foods. Energy foods include rice

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Table 1. Recommended dietary allowances (RDA) of specific nutrients per day for Filipinos.[a]

						Vitamin A value					
	Body wt (kg)	Energy (Kcal)	Protein[b] (g)	Calcium (g)	Iron (mg)	Retinol equivalent (μg)	I.U.	Thiamine (mg)	Riboflavin (mg)	Niacin (mg equivalent)	Ascorbic acid (mg)
Reference man:											
20–39 yr	56	2580	63	0.5	10	650	4500	1.3	1.3	17	75
40–49 yr	56	2450	63	0.5	10	650	4500	1.2	1.2	16	75
50–59 yr	56	2320	63	0.5	10	650	4500	1.2	1.2	15	75
60–69 yr	56	2060	63	0.5	10	650	4500	1.0	1.0	14	75
70–79 yr	56	1810	63	0.5	10	650	4500	0.9	0.9	13	75
Reference woman:											
20–39 yr	48	1920	54	0.5	18*	550	3800	1.0	1.0	13	70
40–49 yr	48	1820	54	0.5	18*	550	3800	0.9	0.9	13	70
50–59 yr	48	1730	54	0.5	8	550	3800	0.9	0.9	13	70
60–69 yr	48	1540	54	0.5	8	550	3800	0.8	0.8	13	70
70–79 yr	48	1340	54	0.5	8	550	3800	0.7	0.7	13	70
Pregnant[c] (2nd & 3rd trimesters)		+430	+14	1.0	18*	575	4000	+0.4	+0.4	+3	120
Nursing (1st 6 mo)		+550	+28	1.0	18	975	6800	+0.3	+0.6	+4	120
(2nd 6 mo)		+440	+16	1.0	18*	800	5600	+0.3	+0.4	+3	120
Infants 6–11 mo	9	970	25	0.6	9	250	1800	0.5	0.5	6	30
Children 1–3 yr	13	1310	26	0.5	6	250	1800	0.7	0.7	9	35
4–6 yr	18	1640	32	0.5	8	325	2300	0.8	0.8	11	45
7–9 yr	24	1870	37	0.5	7	400	2800	0.9	0.9	12	55
Boys 10–12 yr	32	2270	43	0.7	11	500	3500	1.1	1.1	15	65
13–15 yr	44	2510	59	0.7	12	625	4300	1.3	1.3	17	75
16–19 yr	55	2700	67	0.6	13	650	4500	1.4	1.4	18	90
Girls 10–12 yr	35	2170	48	0.7	18*	500	3500	1.1	1.1	14	70
13–15 yr	44	2200	59	0.7	18*	625	4300	1.1	1.1	15	75
16–19 yr	48	2060	59	0.6	18l*	625	4300	1.0	1.0	14	80

[a]Adapted from Pub. No. 76, Food and Nutrition Research Institute of the National Science Development Board. Figures with a plus (+) sign are to be added to original recommendations for the appropriate age group. It is preferable that those with asterisk (*) be higher than indicated. Supplemental iron is recommended during pregnancy. [b]Net protein utilization 63. [c]For pregnant girls below 20 years old, use the higher RDA.

Table 2. Recommended dietary allowances of specific foods per day for Filipinos.[a]

	Body-building foods							Energy foods				Regulating Foods					
	Whole milk	Fish/meat/ poultry		Eggs		Beans or nuts (dried)	Cereals	Kamote or potatoes/ etc.		Sugar	Fats	Leafy/ yellow vegetables		Vitamin C rich fruits		Other fruits/ vegetables	
	E.P. (g)	A.P. (g)	E.P. (g)	A.P. (pc)	E.P (g)	A.P/ E.P. (g)	A.P./ E.P. (g)	A.P. (g)	E.P. (g)	A.P./ E.P. (g)	A.P./ E.P. (g)	A.P. (g)	E.P. (g)	A.P. (g)	E.P. (g)	A.P. (g)	E.P. (g)
Reference man:																	
20–39 yr	—	210	130	½	20	20	420	180	150	35	35	110	70	65	50	165	110
40–49 yr	—	195	120	½	20	20	410	180	150	30	30	110	70	65	50	165	110
50–59 yr	—	195	120	½	20	20	400	120	100	30	30	110	70	65	50	150	100
60–69 yr	—	175	110	1	40	20	360	120	100	20	30	110	70	65	50	150	100
70–79 yr	200	175	110	1	40	—	280	60	50	20	20	110	70	65	50	150	100
Reference woman:																	
20–39 yr	—	195	120	½	20	20	310	120	100	25	25	110	70	65	50	150	100
40–49 yr	—	195	120	½	20	20	300	120	100	20	20	110	70	65	50	150	100
50–59 yr	—	195	120	½	20	15	270	120	100	20	20	110	70	65	50	150	100
60–69 yr	—	175	110	½	20	15	260	120	100	20	20	110	70	65	50	150	100
70–79 yr	150	175	110	1	40	—	200	60	50	20	10	110	70	65	50	150	100
Pregnant (2nd & 3rd trimesters)	200	+15	+10	½	20	20	+30	120	100	+5	+5	110	70	+65	+50	+75	+50
Nursing (1st 6 mo)	200	+45	+30	+½	+20	20	+70	120	100	+5	+5	+45	+30	+65	+50	+75	+50
(next 6 mo)	200	+15	+10	+½	+20	20	+50	120	100	+5	+5	+45	+30	+65	+50	+75	+50
Infants 6–11 mo	480	50	30	½	20	10	80	25	20	25	10	25	15	40	30	30	20
Children 1—3 yr	240	65	40	½	20	10	100	60	50	25	25	40	25	40	30	50	35
4–6 yr	240	80	50	½	20	10	220	60	50	25	30	45	30	40	30	75	50
7–9 yr	150	95	60	½	20	10	290	70	60	25	30	45	30	65	50	150	100
Boys: 10–12 yr	100	160	100	½	20	15	380	120	100	20	30	80	50	65	50	150	100
13–15 yr	—	195	120	½	20	30	420	120	100	20	30	110	70	130	100	150	100
16–19 yr	—	225	140	½	20	30	450	120	100	30	40	110	70	130	100	150	100
Girls: 10–12 yr	100	160	100	½	20	15	360	120	100	20	25	80	50	65	50	150	100
13–15 yr	—	175	110	½	20	20	360	120	100	20	30	110	70	130	100	150	100
166–19 yr	—	195	120	½	20	20	340	120	100	20	30	110	70	100	75	165	110

[a] Adapted from Pub. No. 76, Food and Nutrition Research Institute of the National Science Development Board. A.P. = as purchased, E.P. = edible portion. Figures with a (+) sign are to be added to original recommendations for the appropriate age group.

Table 3. Amino acid Content (mg/g N) and biological data for milled rice, corn, and wheat flour.

Amino acids and biological data[a]	Milled rice	Corn	Wheat flour (70–80% extraction)
Lysine	226	167	130
Leucine	514	783	440
Isoleucine	262	230	228
Methionine	133	120	91
Cystine	96	97	159
Phenylalanine	303	305	304
Threonine	207	225	168
Tryptophan	84	44	67
Valine	361	303	258
Biological data (rats)			
Amino acid score	65	49	38
PER[b]	2.18	1.12	0.6
NPU(%)[c]	57.2	51.1	—
BV (%)[d]	64.0	59 4	52
Digestibility (%)	97.9	90.3	—

[a] Amino acids are in mg/g N. [b] Protein efficiency rate. [c] Net protein utilization. [d] Biological value

and other cereals, sweet potatoes and other tubers, sugar, fats, and oils. Body-building foods are the protein foods such as fish, meat, poultry, eggs, milk, and dried beans. Regulating foods are fruits and vegetables, such as 1) leafy green and yellow vegetables, 2) vitamin C-rich foods, and 3) other fruits and vegetables not included in the first two groups. In the selection of foods to be recommended, it is important to consider the demand for such foods, their availability and cost, and their nutritive Value.

ENERGY FOODS

Cereals and cereal products generally provide more than half the calorie requirements of most people in East and Southeast Asia. Rice, corn, wheat, and barley are the major cereals consumed. Milled rice dominates the total pattern of cereal consumption. In the Philippines, corn and corn products supply, on the average, one-fifth to one-quarter of the calorie intake from cereals. The caloric contents of milled rice, milled corn, and wheat flour are virtually identical. The large amounts of cereals consumed in most Asian countries are important sources, not only of carbohydrates, but also of protein, iron, and some of the B vitamins. About 30-50% of protein intake is estimated to come from cereals.

The protein content of the three major cereals rice, corn, and wheat are 7, 9, and 12%, respectively, but in terms of amino-acid composition, rice protein is superior in quality (FAO 1970) as shown in Table 3.

Both the amino-acid score and protein efficiency rate (PER) values are higher in rice than in corn or wheat. The limiting amino acids in rice and wheat are lysine and threonine; in corn they are lysine and tryptophan. Supplementation of cereals with foods such as animal products or beans that are rich in these limiting amino acids is essential for better utilization of the protein.

Preliminary studies undertaken in toddlers fed rice-milk and wheat-milk diets (50:50 nitrogen contribution) at an intake of 200 mg N/kg body weight tend to indicate the poorer digestibility of rice protein, which may be attributed to the insoluble nature of the glutelin that makes up 80% of rice protein (B. V. Roxas, unpubl. data).

It has been reported that milled rice, boiled and freeze-dried, has lower true digestibility in growing rats (94%) than raw rice (100%). Several studies of humans confirm the poorer digestibility of cooked rice. Tanaka et al (1975) found that 15 to 20% of boiled rice protein was indigestible to Japanese adults. Fecal samples from toddlers given rice-milk diets were shown to contain intact rice protein bodies (personal communication with N. Harris, University of Durham, England). The water solubility of rice protein decreased during cooking (IRRI 1976).

The high-protein rice varieties developed at the International Rice Research Institute (IRRI) may contribute significantly to the total protein nutriture of most Asians and other rice-eating populations. Nitrogen balance studies, undertaken at the Food and Nutrition Research Institute (FNRI), of preschool children given a rice-fish weaning diet using milled rice samples with 7.7, 10.1, and 11.9% protein, respectively, showed that nitrogen retained per kilogram of body weight increased progressively with the protein content of the rice (Roxas et al 1975). The results of another balance study of preschool children given a rice-mung bean diet containing milled rice with 7.5 and 11.4% protein, showed that the substitution of a high-protein rice variety for a low-protein rice did not adversely change the degree of digestibility and retention of nitrogen in the diet (Roxas et al 1976).

Noodles are among the popular cereal products eaten by Asians. Several types have been prepared from rice, wheat, or mung bean starch. Because children are especially fond of noodles, some high-protein noodle formulations have been developed specifically for children. Rice cakes, bakery products, and puffed cereals are other common cereal products.

Roots and tubers are also energy foods whose major constituent is carbohydrate. Hence, in times of shortage of cereal staples or food scarcity, tubers such as cassava and sweet potatoes have been used as cereal extenders. They have also been used as partial substitutes for wheat in bakery products and other foods. The mixtures are called *composite* flours. In bread making, substituting 10% sweet potato for wheat flour and 20% for all-purpose flour has proved very acceptable in baked goods (Madamba et al 1977).

Yellow sweet potatoes also contribute to the vitamin A value of the diet (900 I. U. [International Units]). When boiled in their skins, especially soon after harvest, they provide 30-50 mg ascorbic acid/100 g. At a workshop on indigenous foods, R. Villareal (1973) gave five other reasons favoring the sweet potato: it has tremendous crop-yield potential; its nutrient yield per hectare is high; as a crop, it is dependable; it is acceptable to most people; it is inexpensive.

Fats and oils are concentrated sources of energy because they provide more than double the amount of calories provided by either protein or carbohydrate. Asian diets are generally low calorie, principally because consumption of fats is low. Besides being an important source of calories, fat provides the unsaturated essential fatty acids, particularly linoleic acid. Most vegetable oils such as corn oil, safflower oil, and peanut oil, contain a large percentage of linoleic acid, but coconut oil, the main oil used in the Philippines, does not. A beneficial public-health measure might be to blend coconut oil with other vegetable oils at a ratio calculated to provide adequate amounts of essential fatty acids. Because of its high content of vitamin A, shark-liver oil might be considered in the fortification of fats and oils; red-palm oil, rich in vitamin A precursors, might be another possibility in oil blending. Such fortifications might help solve the vitamin A deficiency problem in many developing countries.

Sugar is another source of calories. Nutritionists classify sugar as a source of "empty calories" because it does not provide anything other than energy. Unrefined sugar does contain some minerals (calcium and iron), but these are lost during refining. Brown sugar is, therefore, more nutritious as well as cheaper. In a tropical climate, the greater proportion of sugar may be consumed in beverages such as soft drinks and juices.

BODY-BUILDING FOODS

The major food group of body-building foods is composed of protein-rich foods of either animal or plant origin. Sources of high-quality proteins are meat (lean), milk and dairy products, poultry and eggs, fish and shellfish, dried beans, and nuts. Besides being rich sources of protein, they are sources of additional energy needed by the body to utilize protein for maintenance and tissue building. They also supply vitamins and minerals such as iron and the various B vitamins. One protein food might be more suitable in meeting requirements than another, mainly because of amino-acid content.

Meat has been considered more prestigious than fish, probably because meat is less available and hence more expensive. However, in

Table 4. Amino-acid content and score of beef, fish, egg, and blood meal.[a]

Protein and amino acids[b]	Beef and veal	Fish (fresh all types)	Hen's egg	Blood meal
Protein (G %)	17.7	18.8	12.4	
Isoleucine	301	299	393	70
Leucine	507	480	551	782
Lysine	556	569	436	568
Methionine	169	179	210	93
Cystine	80	73	152	63
Phenylalanine	275	245	358	467
Tyrosine	225	229	260	227
Threonine	287	286	320	319
Valine	313	382	428	539
Tryptophan	70	70	93	79
Amino acid score	100	100	100	28

[a] Adapted from FAO Nutritional Studies No. 24, 1970. [b] Amino acids are in mg/g N.

terms of protein quality, the amino-acid content and score of fish are comparable with those of meat as shown in Table 4.

To arrive at the amino-acid score, egg protein is used as the reference. Blood meal is listed because of its potential as a source of food protein. Note, however, the great imbalance in the ratio of leucine to isoleucine. Its use as a food supplement would, therefore, be effective only if the level of isoleucine were raised by proper supplementation with other protein foods.

Aside from animal proteins, dried beans are a good alternative source of complementary protein. They are nutritionally important among vegetable foods because of their relatively high protein content, which is about twice that of cereals. Wide variation in protein content (between 18 and 32%) has been reported in various varieties of the same legume. It could be the result of both varietal differences and growth conditions (Bressani 1973). The higher protein content in beans is accompanied by higher levels of methionine, lysine, and tryptophan.

The nutritive value of some dried beans consumed in the Philippines and in neighboring countries is shown in Table 5. Except for chick-pea, the beans are indigenous to the Philippines. The data on amino acids were determined from raw samples at the FNRI (A. Aguinaldo, unpubl. data); biological data were obtained from a study of growing rats fed cooked beans (Gonzales et al 1972).

In general, bean protein is high in lysine and is a good supplement to cereal grains. Beans are, however, low in sulfur-amino acids and in tryptophan. These deficiencies can be offset to some extent by cereal proteins, and to a large measure by animal protein. The biological value of the amount of absorbed nitrogen retained in the body has been found to be low in most seed legumes. However, PER studies by Gonzales (1974),

Table 5. Nutritive value of dried beans.

Amino acids and biological data[a]	Soybean	Mecan pea	Chick-pea	Mung bean	Cowpea	Pigeon pea	Rice bean
Isoleucine	320	285	355	286	340	258	264
Leucine	470	495	580	527	584	466	506
Lysine	344	427	515	489	501	427	420
Methionine[b]	79	—	65	33	73	32	—
Cystine[b]	83	—	74	44	68	61	—
Phenylalanine	302	341	397	346	366	478	349
Tyrosine	219	197	156	118	174	118	139
Threonine	304	266	110	209	151	131	127
Valine	306	358	426	354	463	335	406
Biological data[c]							
BV(%)	72.8[a]	—	78	54	60	62	74
NPU (%)	61.4[a]	—	62	42	46	40	51
Digestibility (%)	90.5[a]	—	80	77	76	65	69
PER	2.32[a]	1.72[d]	1.68[b]	2.12[b]	—	1.54[b]	2.04[d]

[a]Amino acids are in mg/g N. [b]From FAO Nutritional Studies No 24, 1970 [c]BV = biological value. NPU = net protein utilization, PER = protein efficiency rate [d]Miranda et al (1974)

in which various formulations whose common ingredients were rice, mung bean, and coconut flour were used, showed that PER values are much improved in beans and, in fact, are comparable with the PER of casein. The FAO has compiled the amino-acid content and biologic data for a large number of foods, food combinations, and fortified foods (FAO 1970).

Besides dried beans, oilseeds, such as peanuts and coconuts, are potential sources of dietary protein. The Philippines processes about 45% of the world's coconut production. The present method of processing is copra making (sun-or kiln-drying of mature coconuts), by which the oil is extracted. After extraction, the oil cake by-product is fit only as animal feed. Hagenmaier (1975) and Hagenmaier et al (1975) found it feasible to produce food-grade protein products by starting with fresh coconuts. Amino-acid analysis indicated a higher content of sulfur amino-acids than that found in beans. An earlier study by Miranda et al (1968) reported the biologic data for coconut, as shown in Table 6. A feasible and successful wet-processing method would not only bring nutritional benefits, but also boost the economy of coconut-producing regions.

REGULATING FOODS

Regulating foods include fruits and vegetables, which are considered the major sources of minerals and vitamins. With some exceptions, they supply little protein and only a trace of fat. Their calories are, therefore,

Table 6. Biologic data on coconut.[a]

	PER[b]	NPU[c] (%)	Digestibility (%)
Coconut flour	2.15	76	80
Coconut protein, pH adjusted	2.30	71	72
Coconut protein, heat coagulated	2.04	66	71

[a] From Miranda et al (1968). [b]Protein efficiency rate. [c]Net protein utilization.

closely related to carbohydrate content, and for therapeutic diets, i.e., for diabetes or weight-reduction, they have been classified according to carbohydrate content. For nutrition education purposes, however, the group is subdivided into *leafy green and yellow vegetables, vitamin C-rich foods,* and the catchall category *other fruits and vegetables.*

Leafy green and yellow vegetables

Leafy green and yellow vegetables are excellent sources of biologically available B-carotenes, which are the precursors of vitamin A. In diets that are low in animal foods, the consumption of dark green and deep yellow vegetables is very important. Color in this instance is a general guide to food value. The deeper the yellow or the darker the green, the greater the carotene or provitamin A content. Thus, carrots have almost 18 times the vitamin A value of squash, and taro leaves have 6 times the vitamin A value of mustard leaves. Table 7 contains a list of 10 vegetables that are

Table 7. Nutrient content of 10 vegetables rich in vitamin A.

Vegetable	Vitamin A value (I.U.)	Ascorbic acid (mg)	Riboflavin (mg)	Calcium (mg)	Iron (mg)
Taro leaves (*Colocasia esculentum* L.)	20,385	142	0.33	268	4.3
Carrot (*Daucus carota*)	18,520	9	0.04	60	1.7
Horseradish leaves (*Moringa oleifera* Lam.)	11,515	134	0.30	303	3.0
Bitter melon leaves (*Momordica charantia* L.)	9,530	168	0.40	384	3.8
Malabar nightshade (*Basella rubra* L.)	6,390	88	0.15	117	3.1
Sweet potato tops (*Ipomoea batatas* Poir)	5,565	32	0.20	107	6.0
Swamp cabbage (*Ipomoea aquatica* Forsk)	4,826	49	0.24	71	3.2
Chinese cabbage (*Brassica chinensis* L.)	3,600	74	0.13	147	4.4
Mustard leaves (*Brassica integrifolia* O.E Schultz)	3,350	77	0 14	192	53
Squash fruit (*Cucurbita maxima* Duchesne)	1,065	18	0 07	19	05

either outstanding in vitamin A value (FNRI 1968) or are popular in the Philippine diet.

From the data in Table 7, it can be estimated that an intake of 25 g of either taro leaves or carrots, or about 50 g of horseradish leaves or bitter melon leaves, or 100 g of the others, should be sufficient to provide the daily recommended allowance for vitamin A. In the case of squash fruit, more than one serving would be needed.

It will be noted that many of the leafy vegetables in Table 7 provide substantial amounts of ascorbic acid as well, even if some percentage is lost in cooking. Minerals such as calcium and iron, and some of the B vitamins such as riboflavin and fair amounts of thiamine, are important contributions from this group. Some of the young leaves or tops, and the very dark green leaves, were found to have a significantly higher protein content than other leaves. Thus, the protein content of a 100-g sample of horseradish leaves was found to be 5.9 g; of bitter melon leaves, 4.8 g; of taro leaves, 4.4 g; and of swamp cabbage, 3.9 g.

Vitamin C-rich foods

The more popular fruits that are outstanding sources of ascorbic acid are listed in Table 8. Among them, guava, papaya, orange, pomelo, tomato, and, more recently, mango, are available practically the whole year around. Some — melon, tiesa, and mango — are also good sources of provitamin A. Although most fruits do not contain significant amounts of minerals such as calcium and iron, they nevertheless enhance the utilization of these minerals in the diet. Furthermore, ascorbic acid, being an antioxidant, helps maintain iron in the ferrous state in which it is more easily absorbed.

Other fruits high in ascorbic acid, but not readily available, are cashew fruit *Anacardium occidentale* L, with 197 mg; Aztec kwamochill *Pithecolobium dulce* Roxb., containing 133 mg; and strawberry, with 107

Table 8. Vitamin C-rich fruits.

Fruit	Ascorbic acid (mg)	Vitamin A value (I.U.)	Calcium (mg)
Guava *Psidium guajava* L.	126	105	33
Papaya *Carica papaya* L	89	425	23
Mango (green) *Mangifera indica* L	73	135	16
Mango (ripe) *Mangifera Indica* L.	47	2,580	8
Spanish plum *Spondias purpurea* L	51	370	15
Carristel, tiesa *Lucuma nervosa* A. DC	43	2,060	40
Sugar apple *Anona squamosa* L.	43	Tr	41
Pomelo *Citrus grandis* Osbeck	42	Tr	30
Spanish melon *Cucumis melo* L	35	2,140	12
Orange *Citrus nobilis* Lour	35	60	41
Tomato *Lycopersicum esculentum* Miller	29	735	18

mg. Some vegetables and fruits containing less vitamin A still provide worthwhile amounts if two servings are consumed per day. They include pineapple (21 mg), bananas (16 mg), and sapodilla *Achras zapota* L (26 mg). Other vegetables with significantly high amounts of ascorbic acid are cabbage, 62 mg; green pepper, 84 mg; sweet pea, 60 mg; cauliflower, 90 mg; and horseradish pod, 223 mg.

One tropical fruit that stands out among others is the durian *Durio zibethinus* Murr. The flavor of the fruit somehow compensates for its obnoxious smell. Durian surpasses other fruits in its content of thiamine (0.32 mg), riboflavin (0.28 mg), and protein (2.0 g), besides its ascorbic acid (44 mg).

Among the vegetables mung bean sprout, commonly used in many Asian dishes, contributes 52 mg% ascorbic acid, 0.15 mg thiamine, 0.16 mg riboflavin, and 5.6 g% protein.

Other fruits and vegetables

To the large group of other fruits and vegetables belong other plant foods that are not significant sources of any particular nutrient, but nevertheless contribute to the daily food supply. Nationwide surveys have found a preference in the Filipino diet for fruits and vegetables belonging to this group. Besides cereal grains, it is the only food group that is taken in the recommended amounts. The list of the more popular vegetables is in Table 9.

The legume vegetables or their young pods contribute fair amounts of protein. Winged bean has 0.24 mg% thiamine and 0.09 mg% riboflavin,

Table 9. Vegetables popular in the Philippines and some of their nutrient components.

Vegetable	Protein (%)	Ca (mg)	Fe (mg)	Vitamin A value (I.U.)	Ascorbic acid (mg)
Eggplant *Solanum melongena* L	10	30	0.6	130	5
Yard-long bear: *Vigna sinensis* Fraw	28	42	0.3	570	22
Bitter melon *Momordica charantia* L	09	32	0.9	335	55
Chayote *Sechium edule* SW	04	20	0.3	50	16
Cabbage *Brassica oleracea* var *capitata* L	17	64	0.7	75	62
Okra *Hibiscus esculentus* Moench	18	120	0.8	240	17
Radish *Raphanus sativus* L	06	32	0.6	Tr	25
Sponge gourd *Luffa cylindrica* M. Roem	06	16	0.6	45	7
Winged bean *Psophocarpus tetragonolobus* DC	27	64	0.1	545	15

Table 10. Nutrient content of the winged bean (per 100 g fresh weight).

Nutrient content	Immature pods	Seeds	Tubers	Leaves	Flowers
Water (g)	76.0– 92.0	6.7– 24.6	54.9-65.2	64.2 – 77.7	84.2
Protein (g)	1.9– 2.9	29.8 – 37.4	12.2–15.0	5.7 – 15.0	5.6
Fat (g)	0.2– 03	15.0– 20.4	0.5– 1.1	0.7 – 1.1	0.9
Fiber (g)	1.2– 26	5.0 – 12.5	17.0		
Calcium (mg)	63.0–330	204 –370	40		
Iron (mg)	1.3– 17	9.6– 11.83	30		
Thiamine (mg)	0.06	1.4			
Riboflavin (mg)	0.12	0.2			

okra has 0.08 mg% thiamine and 0.09 mg% riboflavin, while the long bean has 0.12 mg% thiamine and 0.13 mg% riboflavin.

Recently, a very thorough report by a Study Committee of the National Research Council of the US National Academy of Sciences (1975) focused on the excellent possibility of increasing the utilization of winged beans in the humid tropics. The study was conducted in Papua, New Guinea. The entire winged bean plant was reported to be edible: the green pods, mature seeds, flowers, shoots, and tubers. Winged beans appear to have a rather exceptionally high content of many nutrients, as shown by the values expressed per 100 g fresh weight (Table 10).

In the Philippines the young green pods are eaten as a vegetable dish, but the other parts of the plant, as far as I know, have not been utilized for human consumption. It is indeed a challenge to investigate this plant for possible development as a major cultivated crop.

The nutritive value of the mature seed is similar to that of soybeans and is superior to that of peanuts. Flour from winged beans has even been reported to be suitable as a milk substitute in the treatment of kwashiorkor. In another report (Karakoltsidis and Constantinides 1975) okra seeds were found to have some potential as a protein source. A comparative evaluation of winged bean seeds, okra seeds, soybean, and casein is presented in Table 11.

Like the soybean, winged bean seeds contain a trypsin inhibitor, but this can be destroyed by boiling the seeds for 30 minutes, or soaking them in water for 10 minutes. No antinutritional factors were found in the PER values of raw and cooked okra seeds.

The food values of other fruits common in many tropical countries are shown in Table 12.

Bananas, a perennial fruit in the tropics, have become an export item as fresh fruit, as chips, as flour, or as a puree. The banana is a bland fruit well tolerated by both the very young and the elderly. In view of the high prevalence of undernourishment among young children, which generally starts as early as the weaning period, we should take a closer look at

Table 11. Comparative evaluation of winged bean seeds and okra seeds with soybean and casein (g/100 g protein).

Amino acid[a] and biological data	Winged bean	Okra	Soybean	Casein
Lysine	7.4–8.0	8.0	66	88
Isoleucine	4.9–5.1	4.7	58	54
Leucine	8.6–9.2	8.5	76	95
Methionine	1.1	13	11	28
Cystine	1.6–2.6	15	12	04
Tryosine	3.2	36	32	58
Phenylalanine	4.8–5.8	47	48	52
Threonine	4.3–4.5	44	39	47
Tryptophan	1.0	-	12	-
Valine	4.9–5.7	E4	52	67
Biologic data				
PER[b]	2.4	34	2 10	3 04[c]
NPU(%)[d]	55.0	-	56 0	73 2

[a] Amino acids are n g/16 g N. [b]Protein efficiency rate. [c]Skim milk. [d]Net protein utilization.

Table 12. Food values of fruits common in tropical countries.

Fruit	Protein (g)	Calcium (mg)	Iron (mg)	Vitamin A value (I.U.)	Ascorbic acid (mg)
Banana *Musa sapientum* L var. *cinerea*	1.2	9	07	25	16
Jackfruit *Artocarpus heterophyllus* Lam	1.4	23	11	175	5
Santol Sandoricum koetjape Merr	0.7	11	12	328	14
Avocado *Persea americana* Mill.	1.0	18	09	135	11
Pineapple *Ananas comosus* Merr	0.4	19	02	15	21
Watermelon Citrillus vulgaris Schrad.	0.1	8	02	170	6
Star apple *Crysophyllum caimito* L	0.7	17	04	10	7

this ordinary fruit and see how we can use it to alleviate malnutrition. With the currently available technology, banana puree can be used as a base forweaning foods. Such use could very easily absorb the banana surplus, or rejects, from large plantations. In areas where the fresh fruit is available, the mashed banana is an ideal carrier for some high-protein foods such as dried milk, cocopro syrup (the product of Dr. Hagenmaier), fish-protein concentrate, and precooked high-protein products prepared from indigenous sources.

I would like to point briefly to the unfortunate experience of countries where processed products are prepared without any thought for nutritional considerations. Some food technologists are more concerned about the acceptability and, of course, the profitability, of processed foods; nutritionists, on the other hand, are more concerned with health returns from processed foods. These two groups apparently have never cooperated in planning processed foods that would be beneficial to a country. The resultant proliferation of junk foods far better kept out of the marketplace should, therefore, surprise no one,

In the foregoing presentation, I hope I have indicated some areas in agriculture, food technology, and nutrition where the agriculture, nutrition, and food-science sectors could readily assist in the resolution of the problems of malnutrition in the Philippines. The protein-calorie problem alone is a staggering one to face, but with the assistance of all concerned, it could be surmounted in the near future.

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Discussion

Dr. Intengan noted that the protein in brown rice is less digestible than the protein in undermilled and well-milled rice. The body's apparent retention of protein from undermilled and well-milled rices was comparable. In cooperative studies with the IRRI, protein in milled rice was found to be less digestible to preschool children than the protein in wheat flour. True digestibility of rice protein is 85% and that of wheat flour protein is 90%. Studies on rats by Dr. B. O. Eggum in Copenhagen showed that cooking reduces the digestibility of the protein in milled rice, but a corresponding increase in chemically nutritive factors results in comparable net protein utilization (NPU) values for raw and cooked milled rice. Evidently, the poorer-quality proteins in milled rice are denatured during cooking and are excreted undigested in the feces of both rats and humans.

The protein quality of milled rice relative to egg protein is higher in humans than in rats. In rats, the NPU is 92–94% for egg and 57-49% for rice. Thus, the relative protein value (RPV) of rice is 63% that of egg protein. In 9- to 17-month-old infants, the NPU is 71% for egg and 51% for rice, equivalent to a relative protein value of 73% for rice relative to egg. In fact, the limiting amino acid (lysine) in rice cannot be detected in humans, but is readily demonstrable in rats. Rice protein is so close to animal protein that it is considered a waste of effort to attempt to further improve the quality of rice protein. Development of new strains of rice should concentrate on increasing protein quantity.

In 1966, IRRI started a development program to increase the protein content of rice from 7% to 9% without sacrificing yield or grain quality. The genetics of protein in the rice endosperm is complex, and screening techniques are greatly influenced by environmental factors such as time and rate of nitrogen fertilizer applications, spacing, and availability of solar radiation 45 days before harvest. The need to incorporate resistance to diseases and pests and to preserve the yield factor in high-protein rice has complicated development efforts.

Chemical studies have shown that a major part of the increased protein content is retained when the rice is milled. Higher-protein rices have organoleptic properties similar to those of low-protein rices, but are more resistant to abrasive milling and require a slightly longer cooking time. Digestibility of protein is not affected by protein content. Protein quality studies based on amino-acid score (lysine), NPU, PER, relative protein value (RPV), and relative nutritive value (RNV) in growing rats, and nitrogen balance studies in adults and preschool children in nutrition laboratories revealed that protein quality drops only slightly when the protein content of rice is increased from 7 to 9% and that protein content is the major determinant of the nutritional value of rice. Growth studies in children are being planned to determine the practical value of replacing low-protein rice with high-protein rice in an 80% rice diet.

The RNV of undermilled and well-milled rice was discussed. The lower digestibility of bran (aleurone layers) is due to its thicker cell walls. Morphologically, the protein bodies in aleurone layers are different from those in the endosperm. High-protein flour from the outer layers, obtained by overmilling the rice, had a lower digestibility factor in children than whole milled rice. A contributing factor is the presence of some crystalline protein bodies (crystal lattice fringes) in the subaleurone layer of the endosperm (two outermost cell layers).

In the Korean diet, barley and millets are important cereals, and seaweeds are important sources of mineral, iodine, and protein. In Korea, sweet potato could be grown and its high productivity (energy production) is described, but it is not in great demand.

In addition to agricultural efforts to improve the nutritional value of food crops, either fortification or more efficient processing can enhance nutrient value.

Banana powder may be obtained from rejects of the Cavendish banana industry in the Philippines, a loss estimated to be 160 t daily. The powder could be an important source of food energy, and may be used in place of pectin and as an ingredient in baby foods. The protein concentrate from coconut, prepared by the Hagenmaier process in Cebu, Philippines, has high nutritional value.

The nutritional value of foods: workshop summary

RICE AND OTHER STAPLES

Rice is the principal staple in many areas of Southeast Asia, but it is supplemented with other staples such as sweet potato, cassava, or corn. It was agreed that from a nutritional standpoint, selective breeding of rice to raise its protein content from 7% to 9%, if achieved without sacrificing yield and grain quality, would far outweigh any gains in raising the protein quantity of cassava. Any effort to increase the protein content of cassava would be of little nutritional significance because the small amount of protein in the tuber is of extremely low quality. However, the use of cassava as a substrate for the growth of unicellular microorganisms to yield single-cell proteins for animal feed should be considered where cassava is plentiful. In addition, increasing the protein content of cassava may raise the proportion of that cereal staple in the diet.

The prospects of improving the carotene content and protein quality of the sweet potato by selective propagation are good, but it is doubtful that its protein level can be raised by similar techniques. In Indonesia, where much cassava is eaten, the nutritionally superior sweet potato is now encouraged as a substitute.

Corn should have an important place in the Southeast Asian diet, because it supplies substantial amounts of protein and carotene in addition to energy.

LEGUMES

The need to encourage greater consumption of legumes in the rice-based diet is widely recognized. Soybeans, mung beans, and four-angled beans (winged beans) were discussed. The major drawback to their production, particularly that of soybeans and mung beans, is their low yield in Southeast Asia, which may be related to the problem of nitrogen fixation in the soil. Selection of mung bean strains with a lower phytate and zinc content is possible. This is relevant to the utilization of iron and calcium. The problem of phytate is not so significant in mung bean sprouts.

Four-angled beans appear to be a hardy legume that can be grown easily in most backyard gardens. However, the young pods that are commonly eaten have a much lower protein content than the dry seeds. It was mentioned that the tubers and leaves are also rich in protein, and agriculturists are asked to explore their potential dietary use.

FATS AND OILS

Fats and oils can make up for the deficit in calories in Southeast Asian diets, and their greater consumption also reduces the bulk of food that must be eaten. Refined palm oil, which is comparatively more unsaturated (linoleic acid content is about 10–11% of total fatty acids) than the highly saturated coconut oil, is now gaining wide acceptance as a cooking oil in Malaysia, and its use has spread to neighboring Thailand.

There is a need to blend the highly saturated coconut oil with 10–15% vegetable oils rich in polyunsaturates (for example, soybean or corn oil), if the oil is used in a food that is more or less the sole food for a group, e.g., a milk product fed to infants. In Burma, the potential for increased consumption of sunflower-seed oil is good. Edible oils should be selected on the basis of their essential fatty acid content as well as their energy-yielding potential.

MINERALS

The iodization of salt should be extended to all countries where endemic goiter exists. The vehicle for iron fortification was discussed; the availability of iron in a readily utilized form and use of chelating agents for this purpose were mentioned. In Central America, sugar has been successfully fortified with vitamin A palmitate with no effect on flavor. The wise use of monosodium glutamate in Southeast Asia may render it a useful vehicle for vitamin A fortification.

VEGETABLES

The desirability of selective breeding of vegetables with low oxalate content was discussed. This has relevance to calcium, iron, and zinc utilization. Investigations can be conducted by the Asian Vegetable Research and Development Center in Taiwan.

MEAT, MILK, AND FISH

Increased meat production appears to have low priority because those who need meat most are rarely able to afford it. In Malaysia, farmers are encouraged to keep cows, with the Department of Agriculture guaranteeing the purchase of all milk. The milk is cooled, pasteurized, packed, and sold to school children on a nonprofit basis. A source of additional income is guaranteed for the farmer, and the regularconsumption of milk improves the health of the children.

Small numbers of poultry per family can forage for food without competing with humans for grain. Although too valuable for the poor farmer to

Table 1. Foods that should be promoted.

Foods	Type of promotion needed[a]	
	Production	Consumption
Energy foods		
Cereals other than rice	+	+
Root crops	+	+
Oil (such as coconut and peanut)	+	+
Others – jaggery (Burma)	+	-
Protein foods		
Legumes soybean, mung bean, peanut	+	+
Cowpea	-	+
Fish	+	+
Meat (pork and/or beef)	+	-
Eggs	+	+
Regulating foods		
Green leafy vegetables (spinach, swamp leaves, water convolvulus, etc.) (identify Indigenous vegetables rich in vitamin A and/or iron that should be promoted.)	+	+
Tomatoes	+	+
Fruits (avocado, papaya, orange)	+	+
Others - milk, banana	+	+

[a]+ = should be promoted, - = need not be promoted.

eat, poultry can provide some cash income.

Greater efforts should be made to construct fishponds. In some areas marine fish supplies are dwindling because of overexploitation.

WEANING FOODS

The processing of weaning foods using indigenous ingredients should be given high priority by food scientists.

MYCOTOXIN CONTAMINATION

Practical measures for the prevention of mycotoxins in crops stored at high moisture content should receive urgent attention from food scientists.

FOODS TO BE PROMOTED BY EDUCATION IN NUTRITION

The group appreciated that foods to be recommended must be cheap, readily available (already produced), and already acceptable (food preference). Regional differences exist in eating habits and food preferences. Table 1 lists nutritious foods that should be promoted to overcome nutrient deficiencies prevalent in the region – in calories, protein, and vitamin A. Education campaigns and promotion are required to increase either production, consumption, or both.

The group also recommended encouragement of breast-feeding.

FOODS REQUIRING IMPROVEMENT IN NUTRITIONAL VALUE

Foods whose nutritional value should be improved, and the contribution of agriculture and food science to this goat were discussed. Emphasis was given to the potential of food science for making processed foods more nutritious – noodles, snack foods, and beverages may be vehicles for protein and vitamin fortification without sacrificing consumer acceptability.

A nutritional component of agriculture is a relatively new concept in the region. Agriculturists can help increase food production through better plant breeding and agricultural techniques. Food scientists can help by processing excess crop yields, thereby reducing postharvest losses. The experience of Taiwan was cited: the use of cheap and simple village-level food-processing technology and locally fabricated equipment provided inexpensive, acceptable food products throughout the year. Multiple cropping must be encouraged to add diversity to foods in the diet to supplement deficiencies in the staple crop.

A critical review of the losses in the rice postproduction system in some Southeast Asian countries

DANTE B. DE PADUA

ABSTRACT

Double-cropping and increased yields of rice have rendered existing postharvest facilities and practices inadequate. The result is that losses significantly negate the increased yields. The losses incurred are both physical and economic due to biological deterioration of the harvested grain. These losses are incurred throughout the chain of operations from farm to consumer. The difficulties are technological as well as socioeconomic in nature.

To provide the needed capability in the postproduction delivery system, the rice industry must be analyzed as a total system and in the light of social, economic, political, and physical conditions prevailing in the region. An operational model must be developed and the appropriate technology identified, adapted, or designed to suit the model. This model must be compatible with the national aspiration of creating progressive rural communities centered around rice farmers.

Development of an effective postproduction delivery system for rice will contribute toward achieving self-sufficiency and will enhance the economic conditions of the rice farmer by allowing him greater participation in the rice business.

INTRODUCTION

An awareness of needs in rice postharvest operations has existed for more than 20 years – since agricultural production changed from subsistence to commercial farming. As rice yields improved, development planners started to call postharvest operations a second-generation

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This Paper draws heavily on insights and materials derived from a study on the “State of the Art of Rice Post-Harvest Technology in the Philippines, Malaysia, Thailand, and Indonesia,” commissioned by the International Development Research Centre and which has been presented in other workshops and conferences.

requirement. The operations, however, quickly became second-generation problems.

The postharvest–more accurately called postproduction–system is the entire process for delivering rice to consumers from its paddy form on the farm. The system includes the technical operations of threshing, cleaning, drying, storing, milling, grading, packaging, warehousing, transporting, and retailing.

The aim of the Philippines, and many other rice-producing countries, is self-sufficiency in rice. But while there have been breakthroughs in production at the farm level, the Philippines is not yet completely self-sufficient, and therefore can ill-afford the estimated 10 to 37% losses of the rice harvest in the postproduction delivery system.

The Philippines' gross rice production is estimated at more than 6.25 million metric tons. The need for taking a critical look at the postproduction system and applying the necessary corrective measures, or completely overhauling the system is clear in the fact that a highly realizable 5% decrease in losses means 0.3 million metric tons of paddy or 0.2 million metric tons of milled rice for consumers. That 5% decrease has a product value of nearly US$6 million.

Within the interdependent matrix of components of the rice industry, an innovation, a restructuring of the industry, ora policy decision affects the lives of the 80% of the Filipino population because they depend in one way or another on rice for their livelihood. Rice is a strategic commodity and the postproduction system is a vital component of the rice industry and thestruggle for self-sufficiency. The margin of operation for the post-production delivery system accounts for 47% of the value of the product off the farm – a US$400 million industry. If business has not moved in or thrived in this sector, I suggest that there issomething wrong somewhere in the system. Programs have come and gone with only monuments in the countryside as reminders of their past glories. Today, the call is for far-sighted planning and a look at the situation from all angles.

THE RICE POSTPRODUCTION INDUSTRY

It is estimated that of the Philippines' gross rice production, about 30% is retained in the rural areas for local consumption, 55% goes into the commercial channels for retail, and 15% is channeled to the National Grains Authority (NGA) system as buffer stocks.

Governmental grain agencies like NGA, LPN of Malaysia, and BULOG of Indonesia have their own system and facilities for procurement, storage, processing, and distribution. They are, however, not good models for the postproduction system. They are subsidized and operate against natural economic forces by buying at support prices during the peak of the harvest season, when prices are depressed, and selling at ceiling prices during lean periods. These governmental agencies are, however, good proving grounds for technological innovations.

For development planning, there must be more concern for the 85% of the rice crop that is handled by the private sector, and the efficiency of its operations. Categorized at the various operational levels, private sector loss ranges are estimated as:

• Harvesting[1]	- 1 to 3%
• Handling[1]	- 2 to 7%
• Threshing[1]	- 2 to 6%
• Drying[1]	- 1 to 5%
• Storage[2]	- 2 to 6%
• Milling[2]	- 2 to 10%
Total range of losses	10 to 37%

It appears that 10% are unavoidable losses, but it would be unrealistic to expect complete reduction of the other 27% of losses. I earlier mentioned a conservative figure of 5%, and I will elaborate on where a 5% reduction in losses may be aggregated.

THE STATE OF THE ART AND THE PROBLEMS IN TECHNOLOGY

A success story is an activity that achieves its goals. A business venture in the rice industry should be evaluated on its returns on investment, and its sustained operations and growth in the real world. National planners should be concerned with the total development and growth of the rice industry. As for the engineers concerned with the technology, the concern is with efficiencies based on output-input ratios and the quality of theoutput of each unit operation. There is, therefore, much concern about the causes of the losses, the nature of the losses that account for low efficiencies, and the losses that can be realizably avoided. Technical efficiency is not the only requisite for success. Economic feasibility and social acceptability are just as important. I will illustrate this point shortly.

The measurement and analysis of efficiencies, or the estimates of losses, are guided by certain criteria. Consumer preference is expressed in the cooking and eating qualities of the grain, which in turn are related to the varietal characteristics and the manner of handling and processing. In general the preference is for biologically aged rice, that is, well polished and unbroken.

The criteria for quality of paddy rice include moisture content, purity, cracked kernels, damaged and immature kernels, yellow and fermented

[1]From Samson and Duff (1975)

[2]Estimate based on measurements by participants in postharvest training courses during a 5-year period.

kernels, mixtures of red rice, mixtures of weed and other crop seeds, and mixtures of other varieties. These criteria for paddy are important for estimating the milling potential of the grain.

The criteria for quality of milled rice include moisture content; head rice; broken rice; brewer's rice; chalky and immature kernels; yellow, fermented, and damaged kernels; mixtures of red rice; mixtures of foreign matter; mixtures of other varieties; degree of polish or removal of bran layers; degree of whiteness; and mixtures of paddy.

Tolerances specified for each category provide a set of standards, and the grain can be graded against those standards. The Philippine standards are patterned after U.S. standards, which have stringent requirements compared to the prevailing conditions of quality of both paddy and milled rice. The result is that practically all Philippine production cannot meet even the lowest grade of the standards set.

The standards, therefore, are not functional, and cannot be implemented. The trade, therefore, resorts to its own standards, which vary from region to region and from trader to trader, creating a situation wherein a commodity cannot be accurately and universally described in terms of its quantity and quality. Misrepresentation is the rule rather than the exception. In the absence of an implementable set of standards, quality control and inventory control cannot be effectively undertaken. The NGA is undertaking a revision of the Philippine standards but, in the meantime, it is with the current criteria for quality that we attempt to understand the causes and nature of the losses that occur.

There are physical and economic losses to consider. The physical losses are due to:

1. shattering of the grain from the panicle of the standing crop because of late harvest or harvesting operations,
2. immature kernels due to nonuniform ripening,
3. unsound kernels due to physiological disturbances during crop growth,
4. rodent and bird infestation,
5. spillage during handling and storage,
6. grain kernels blown away with the chaff and hulls during cleaning and milling,
7. low milling recoveries due to the damage inflicted on the grain before it reaches the mill,
8. low milling recoveries due to inherent inefficiency of the mill or its improper operation,
9. low milling recoveries due to overpolishing, and
10. wasteful cooking and eating practices.

The losses due to deterioration in quality are caused by:

1. late harvesting,
2. remoistening of the partially dried grain, which causes fissuring,

3. delay in drying or improper handling of grain before drying, which causes heat stack burns, or heat discoloration — the yellowing of kernels – and fermentation resulting in the brownish discoloration,
4. improper drying, which also causes fissuring and results in a high percentage of broken kernels and low milling recoveries,
5. nonuniform drying of the kernels resulting in damage to the grain in storage,
6. unsuitable and inadequate storage facilities,
7. improper storage practices resulting in moisture migration, reabsorption or outright condensation of moisture from the humid storage atmosphere,
8. infestation and contamination of the stored grain by rodents and insects,
9. infestation by fungi resulting in contamination with mycotoxins,
10. contamination with stones, and other foreign matter,
11. mixing of varieties,
12. improper milling, and
13. prolonged storage of the milled rice in unsuitable containers and warehouses.

To obtain a greater understanding of the cause and nature of rice losses, a sampling-survey of grain at the different levels of operation was initiated last year at the University of the Philippines at Los Baños. A large number of samples are obtained at random at each loss level from the standing rice crop to the consumer's table. All samples are tested against the criteria listed, and the data statistically analyzed.

The initial information obtained indicates that the dry season crop produces relatively good quality grain with a potential milling recovery of 68.5% and 89.2% head grain. There is no appreciable damage incurred in the handling until after the drying operations. There is a small but significant decrease in quality in storage, an appreciable damage to the grain in the milling process — a reduction of 12.4% head grain from samples in the commercial conotype mill, and 31% in the *kiskisan* (steel huller) mills. The decrease in head grain recovery is closely correlated with decrease in total milling recovery. There is, therefore, room for improvement in efficiency in the milling technology. If thissampling surveywould be expanded to other regions or to a national scale, information on the actual quality of grain could pinpoint the weaknesses in the chain of operations and, more important, provide a basis for developing a functional set of standards.

Farm production

Rice farms in the Philippines, and in most of Asia, are from 0.5 to 3 ha/farmer. Several rice varieties are planted, usually as insurance against pest infestation. The level of mechanization is low, with available horsepower on the rice farm estimated at 0.05 hp/ha compared with Japan's 4 hp/ha. The yields where high yielding varieties are used average 1.6 t/ha. These are the production patterns that the postproduction sector must be compatible with.

The rice cropping patterns are seasonal in the main rice-producing regions, with about a three-month spread for the harvesting season. When irrigation is available, continuous cropping, or at least two distinct crops, are grown. In the Philippines one crop is harvested during the hot dry season months of March, April, and May and the other during the monsoonal season of September, October, and November. This cropping pattern dictates the capacity requirements for drying and storage, and the type of facilities needed. The processing plants should have sufficient storage capacity to keep their mills operating between the harvest seasons. The drying plants must have sufficient capacity to handle the peaks, particularly during the wet season harvest.

Increased output from the processing plant can be achieved only with good quality paddy. Quality control therefore starts on the farm. Too often, the emphasis is only on yields, but high farm yields are often negated by low milling recoveries due to a high percentage of partially filled kernels. Agronomists indicate that good cultural practices start with uniformly healthy seeds, thorough land preparation, even fertilizer application, and good water management. These are imperatives not only for higher yields but also for uniform maturity of the crop with full sound grains. The incentive to produce good quality grain must be considered in the price support as well as in the trading practices. Here again, the need for a functional set of grain standards is underscored.

Harvesting and threshing

Harvesting, threshing and field cleaning are farm operations that critically affect the postproduction sector. Mechanical harvesters for reaping, binding, threshing and cleaning are exceptions. The combining of all of these operations in a single machine, such as are available from the USA and Europe, is not suitable for the small Asian farms. The smaller Japanese combines have not gained acceptance, primarily because of high costs, exacting field requirements, and high field losses.

Studies at the International Rice Research Institute have shown that delay in harvesting produces lower yields due to lodging, shattering, bird damage, and rodent infestations. It also produces lower milling yields and lower head grain recoveries. The dry season crop has a grain moisture of 20-21%. Leaving the crop in windrows after reaping in good weather does not damage the grain, but heavy dew or drizzle that remoistens partially dried-out grain induces fissuring that results in low milling recoveries.

Partial statistics on our sampling survey on threshing practices indicate that there is less damaged grain after mechanical threshing than after threshing by beating. Threshing by trampling with the feet resulted in a significantly 6% lower milling recovery, with a high 15% more brokens compared with beating and mechanical threshing. The reason for this has not been ascertained.

The wet season crop, harvested with grain moisture at 24-28%, is much more difficult to handle. This wet harvest has to be threshed, cleaned, and dried within 24 hours, unless a predrying facility is available. The crop cannot be left in windrows or stacked in the field. Delay in the handling results in moiding, heating, fermentation, and even germination - biodeterioration. The existing mechanical threshers that work so well for the dry season crop have difficulty working on the wet season high moisture crop, because of choking and clogging by the wet straw. The difficulty in handling the wet season crop results in much lower milling recoveries, and much poorer quality grain. Work in the UPLB laboratories indicates that high volume aeration with ambient air in predrying bins, or in sack tunnels, can effectively arrest the biodeterioration of quality.

In Indonesia, the harvest seasons are also March to May and September to November. The wet season is from October to April. Both crops therefore are partly hit by the rains. Harvesting and threshing by machines are currently being tried. Indonesian agricultural officials estimate that about 40% of their crop is still harvested as stalk paddy. The 40% roughly represents the traditional varieties, and 60% comprises the new high yielding varieties of PB5, PB8 (IR5 and IR8), and *si-ampat* (C-4). Stalk paddy is cut about 12.5 cm below the panicle and bundled in 8-cm-diameter sheaves. The new varieties are not handled as stalk paddy as they shatter easily.

Stalk paddy at the time of harvest has a grain moisture of 20-25%. The bundles are dried in the sun for a day and then hauled to the villages, with grain moisture at 18-20%. Another day of drying brings it down to 14-15%, after which it is stored in open sheds, or in the open in pyramidal stacks until milling. The yard stacks are arranged with the grain panicle to the outside so that rainwater flows over them without soaking in. This practice eliminates the need for sacks and storage sheds. BULOG estimates 17-18% loss from this method of harvesting and handling.

As already mentioned exposing dried grain to humid air plus rewetting causes internal fissuring of the grain, which breaks in milling. The damage due to this method is unestimated. It was, however, observed that output of machines milling stalk paddy exhibited a white chalky or powdery surface with an extremely high percentage of brokens. It is acknowledged that field threshing and proper drying and storage would reduce losses and improve milling quality.

Drying

The inability to dry the harvested crop during inclement weather causes much physical loss because of rotting, and economic loss from the downgrading of the milling quality because of high breakage, discoloration due to fermentation, and heat damage. There is also a potential hazard to health, which has not been evaluated, from molding and possible aflatoxin contamination. Inappropriate drying facilities or improper operation, or both, cause many of the problems. The former is blamed by owners and the latter by suppliers. Many times it is a combination.

The commerical grain dryers used throughout the world use force-heated or natural ambient air depending on the climate. The dryers are either batch type in deep beds or shallow beds, static or recirculated for mixing purposes; or the continuous-flow type intended for multistage drying and therefore provided with tempering bins. Variations are in the design of the grain holding bin, how air is introduced and exhausted, and in operating characteristics, i.e. airflow volume-to-grain ratio and drying air temperature, which influence rate of drying and quality of product.

Drying using a forced heated air system is much more critical for rice than for other grains. Rice is very sensitive to thermal stresses that induce fissuring and cause a high percentage of brokens at milling. High temperature associated with low air volumes, which removesurfacemoisture rapidly, results in poor yield and head grain recovery. The same rate of drying can be effected without loss in yield and head grain by using lower temperatures but higher wet bulb depressions. This in effect has a higher vapor pressure differential, which is the driving potential in the mass transfer phenomena. I belabor this theoretical aspect here as a basis for commenting on the many inappropriate drying facilities and improper operational procedures observed. It is generally understood that rice drying must not damage the milling quality. Needed corrective measures can be made intelligently only if the principles are well understood.

It has been observed that continuous-flow dryers, designed to dry the grain in stages, and therefore require tempering bins, are used improperly. They are often erected without the tempering bins and used (with higher temperature) for one-pass drying. This results in a high percentage of broken grains. It has been argued that, at the peak of the harvest season, more capacity is required to save the crop and that the one-pass procedure is more economical. It is further suggested that the local market does not place a premium price on high head grain that the rice industry is not producing forexport. Thisargument is, of course, in grosserror. A continuous-flow dryer, correctly operated to dry in stages, has about $^1/_4$ to $^1/_3$ the net drying time of continuous drying in one pass, and therefore has 3 to 4 times more drying capacity. The high percentage of brokens is correlated inversely with total milling yields. A high percentage of brokens equals low milling recovery. The gross result is, therefore, uneconomic.

Sun drying of rice in Asian countries is still the predominant practice, even if heated-air dryers are available. The most common arguments given are that sun drying is cheaper, or that the milling quality is better with sun drying, or that artificial dryers do not have the necessary capacity. These arguments may or may not be valid but the fact remains that with double rice cropping in the Philippines, Malaysia, and Indonesia, it is imperative to use artificial dryers if only to realize the full value of the rainy season crop. Only Thailand does not have a drying problem. Only about 4% of Thai production is rained out and that figure is considered manageable.

Despite the recognized need, the acceptance and usage of dryers have not met the required capability. The following observations and conclusions are offered:

1. The acquisition cost of imported grain dryers, and even of local versions, is outrageously high. A batch-type recirculating unit with a capacity of 3 t/hours, excluding the power unit, is marketed for US$9,000.
2. The indiscriminate certification by “experts” of many dryer models, and their subsequent unsatisfactory performance have inhibited the market.
3. Lack of technical know-how in dryer operation has resulted in inefficient operations and poor milling results.
4. Capacities of dryers are incompatible with the other processing equipment.

The problems of high-investment, capital-intensive rice centrals are different.

1. Their dryers have large capacities but cannot cope with the many different varieties and grades received.
2. The delay in bringing in the grain because of harvesting, threshing, and transport limitations nullifies the advantage of having a large dryer. Usually the grain has suffered a loss in quality by the time it reaches the plant.
3. Improper operation due to lack of technically trained personnel results in inefficiency.

In view of the foregoing, the low-cost batch-type farm dryer that farmers or village craftsmen can build from locally available off-the-shelf materials seems appropriate. Its use requires a minimum of fuss, and, operated properly, it does not lower the milling quality or viability of the grain. The concept of the farm dryer also moves the drying from the storage or milling plants to the farms. This could solve the time delay between harvest and drying. The farm units would not eliminate plant drying but merely complement it. At the peak of the harvest season when the grain is wet (26% moisture), the farm dryers can extract the first 8% and arrest biodeterioration of the grain. At 18%, the grain could stand the 2 or 3 days needed to reach the plant where a final drying to the desired storage and milling level of 13-14% can be done.

Rice milling

The unit components in rice milling are the cleaner, stoner, autoweigher, paddy-grader, huller, husk aspirator and sieve, paddy and brown rice separator, return huller, whitener, polisher or refiner, grader, blender, packager, small brokens and bran separator, cyclone collectors, and conveyor system. Not all rice mills incorporate all these components. Some combine two or more operations in one unit. The basic difference in what may be called the traditional mills and modern mills are in the hullers, separators, and whiteners. The traditional mills use the overrun or underrun emery-stone disk hullers and the modern mills use rubber-roll huskers. The traditional mills use compartment-type shaker separators and the modern mills use oscillating specific-gravity-indented plate separators. The traditional mills use vertical-cone emery-stone-coated whiteners, and the modern mills use horizontal air-cooled friction whiteners. The latter may be an emery-stone-coated cylinder or a ribbed steel shaft. There is divided opinion on which type of technology or system is better. Combinations are employed.

Intensive tests in an International Development Research Centre-supported study at UPLB engineering laboratories indicate that rubber-roll huskers have a huller efficiency of 83.24%; the stone disk husker has only 58.23%. This efficiency means less breakage and better hulling performance. On the other hand, another study on the comparative performance of commercial mills under commercial operating conditions, but with controlled paddy samples to eliminate variances due to paddy characteristics, indicated that although the rubber-roll mills had a higher husking performance, the total milling yields and head grain recoveries were not significantly any higher than with cono-type mills with underrun stone disk huskers.

The conclusion is that, with prevailing conditions, the modern rubber roll mill has no real technical advantage over the traditional cono-type mill in a commercial operation. Because the rubber-roll indicated superior performance under controlled laboratory conditions, the critical stage lies in the whitening process and the operational techniques. However, due to the abrasive nature of the rice hull the rubber rolls wear fast. The actual service life varies from 40 t to 100 t per roller. The price of one rubber roller is about US$15 in Malaysia and US$25 in the Philippines.

An economic analysis to determine the cost of milling for the commercial mills studied gave about US$3.30/t higher operating cost for the rubber-roll mills because of the frequent replacement of the rolls. Today the acquisition cost of a 4 t/hour rubber-roll mill with a 4-stage whitener, refiners, and graders is about US$300,000, while a locally manufactured cono-type mill of comparable capacity, but without some of the ancillary components of the Japanese mill, is about US$40,000. It seems, therefore. that for the industry to take advantage of the potentially superior technology of the Japanese mills, local manufacture of mills and training of millers in operational techniques are needed.

A third type of rice mill combines the hulling and whitening process in a single operation and then drops milled rice into a polishing compartment. This mill is known as a planter's mill, Engleberg huller, or one-pass mill. In the Philippines it is called a *kiskisan*. It is commonly used in the villages for custom milling for home consumption and is notorious for breaking the grain. Head grain recoveries are low, in the order of 35% of milled rice. Total recoveries are generally much lower, about 60%, but in some units special shifters are employed to recover the small brokens that mix with the bran. The popularity of the unit comes from its low cost, compactness, and ruggedness. In the rural areas they particularly like the fact that the rice hull is crushed and mixed with the bran, and can be used for livestock feed.

It is estimated that 55% of the milling capacity of the Philippines is in *kiskisan* mills. These mills have a capacity of 0.5 t/hour. Because of the poor milling recoveries, the government had discouraged *kiskisan* use, but with little success. There is no alternative that can compare with its low cost, simplicity, and low maintenance cost. The 1-t/hour Japanese rubber-roll mill with a single horizontal whitener was introduced to replace the *kiskisan* but failed because replacement rollers were too expensive. Because of the large number of *kiskisan* mills in use, its improvement, or replacement with a suitable mill, can mean more milled rice from the paddy harvested.

Storage

Rice is normally stored as paddy at a moisture content of 13-14% and at ambient temperatures. In tropical Asia, where double-cropping is feasible, paddy is usually stored only 4-6 months.

The basic requirements of good storage practice are healthy, clean and uniformly dried grains; and a storage structure that will maintain a suitable environment and prevent entrance of insect and animal pests. The sophistication of storage structures is measured in the convenience in moving the grain in and out of storage, the ease in inspecting the grain or in monitoring the condition of the grain in storage, and the means for conditioning the stored grain.

Storage losses aside from the physical loss due to insect and animal infestation are those due to fungal attack, quality downgrading as a result of color change, or a musty odor. A serious hazard to health are the mycotoxins associated with beriberi or potent carcinogens, which are found in moldy grains.

Rice is hygroscopic and its equilibrium moisture content depends on environment. Hot humid tropical climates normally support grain moisture contents higher than the recognized safe storage moisture of 14% (wet basis). The high humidity fosters fungal activity, higher respiratory rates, and insect infestation. The unfavorable tropical environmental condition, the lack of appropriate facilities, and lack of experience in the practice of bulk grain storage in tropical climates, all make grain storage one of the most critical areas in the processing component.

Paddy is traditionally stored in the Philippines in jute (or synthetic fiber) bags of 50 kilos in flat warehouses. The bags are piled to allow natural convection currents to rise and minimize heating. Fumigation to control insect infestation is normally practiced only in government warehouses. Increased production has led to the establishment of bulk storage facilities. They are either of the bin type within a structure, or the free standing exposed silos. In the latter, moisture migration, heating, fermentation, and total damage have been experienced even for the short storage durations of 3-4 months. A simulated laboratory test by a UPLB graduate student indicated conclusively that the difficulty lies in the *breathing* of the bins. During the day, when the walls of the silos are exposed to the sun, the grains near the walls are heated. The heat is transmitted inward by conduction, the storage atmosphere expands, and the bin *exhales* through its seams. At night the grain cools and the bin *inhales* humid night air. With the night air near saturation and as the silo walls cool, the moisture-laden air near the walls condenses and wets the grain. Inside the silo, natural convection currents due to the temperature gradients cause further moisture migration to other parts of the bin. Solutions to these problems are needed.

Total savings potential

There is much room for improvement in existing facilities and operational practices. In harvesting, threshing, and predrying handling, a 3% decrease in losses is possible by development of suitable equipment and its widespread adoption, and through extension training and proper incentives to emphasize improved quality of farm production.

In drying, the adoption of farm dryers and suitable plant-type dryers, and improvement of operational techniques could reduce losses by at least 2%.

In the storage system, the construction of suitable facilities, and the use of pest control measures will give a 1% decrease in losses.

In the milling system, the replacement of the *kiskisan* with a suitable alternative, the improvement of the premilling handling of the grain to maintain its quality, and the further improvement of the traditional mills and training of millers in operational techniques, will reduce losses by 4%.

That totals 10%, where I started by only earmarking 5%. That gives a 5% factor for safety and for continued *ignorance*.

OPERATIONAL MODELS

I have attempted to define some of the distinguishable elements of the postproduction system to point out causes and effects among some of the elements, and to examine the functional requirements in terms of the existing hardware required and available. The traditional approach has been to impose the hardware and technology of the developed countries on our social, political, and economic environment, hoping that the local environment will adapt. This approach hasn't exactly flourished in the postproduction system. On the other hand, there has not been full exploration of the theory that we adapt the available technology to a development plan that takes cognizance of the idiosyncracies of the local social, political, and economic environment.

I would like to review some of the existing models and add my technical observations regarding them. They may appear to be business models, economic models, or political models, but regardless of what they are, the engineering research and development program can be defined more rationally if we knew the structure of the operational model we are aiming for.

The industry is composed of three primary sectors: the farmers, the millers, and the retailers and consumers. The three are inextricable, interrelated and interdependent. In the traditional structure, these sectors operate independently. As the commodity passes from one hand to the next, each operative element – the farmer, the trader, the miller, the retailer—tries to make the best out of his situation even if he has to do a little manipulation or misdeclaration of quality.

The traditional and predominant postharvest model is the family-owned and operated *kiskisan* and the larger capacity cono-type mills. They are used for custom milling as well as for commercial milling. The cono-type mills usually have a bag warehouse and a drying pavement. They depend on itinerant traders or family connections in purchasing paddy during the harvest season. Sometimes farmers store their harvest with these millers in exchange for the business of milling the grain for the farmer on his instructions. Most of the commercial mills have limited paddy purchasing and storage capacity and run out of paddy to mill between the harvest season. They either close or purchase from other regions of the country to keep the mills operating. Some of the shrewder entrepreneurs, who have the means and are sensitive to factors such as the weather and crop yields, and even government programs that influence the market, do a lot of speculative purchasing of paddy. In 1972 some millers purchased paddy above the support price. When the July-August shortage came around and people had to eat corn grits, the millers had stocks to mill and sell at what the market could bear, even in defiance of the NGA and the government. The next year the novices speculated but the seasoned millers did not. Those that speculated were caught with high-priced paddy they could not mill and sell because NGA had ample stocks to stabilize the prices.

The greatest asset of the family-owned milling plants is their flexibility to meet crisis situations because of their low overhead costs, and their low capacities. They are tailor-made for handling the production of the small Asian farms. But whatever they are today was not the result of a systematic development plan, and perhaps what we need now is to continue with research to improve the efficiencies of their hardware and processes and then get out of the way. These private entrepreneurs will recognize a good innovation, pick it up and handle the implementation without too much fuss.

Another type is the rice-processing complex established by corporate business enterprises. From the agro-based business viewpoint, the storage-processing sector is a production plant that has to satisfy the requirement of its market with a steady supply of reasonably priced products of predictable quality, and farmers as a source of raw material. The business enterprise develops the market for its particular brand of product, but ultimately the consumers indicate their preference. Within its capability the production plant gears itself to provide what is demanded in a manner to maximize its profits.

With the promise of the high yielding varieties and the world grain market demand, a few pioneering complexes have come into being. These are high-capacity plants, ranging from 5 to 25 t paddy/hour. They have storage facilities with capacities to provide carry-over during the lean months between harvest seasons. Their hardware and technology are imported from Europe or Japan. The processing operations are supposed to be fully integrated with the farm production and marketing sectors.

The grain-processing complex could be the answer to needs, yet somehow they do not appear viable. They always seem to lack the operating capital and the managerial efficiency required. The biggest problem seems to be the organization of the source of raw material, paddy, on a basis compatible with the requirements for the operation of the processing plant. These corporations do not own rice production estates, but bank on eitherfreelance procurement or formal linkages with the farmers for their raw material. The linkage concepts such as organizing the farmers into associations and providing them with production inputs, farm extension technician services, crop insurance, or even nominal participation in the processing business, have encountered many social problems. Some have to do with the credibility of big business with the farmer. And because production is not controlled, and the paddy comes in as many different varieties of different grades and in small batches, the processing plant cannot attain its rated efficiencies. A plant on a controlled test run could yield 70% recoveries with 80% head grain from good quality paddy, but the average total recovery over a year of operation is about 60%.

The nontechnical dimension of this model is the inequity in the sharing of the profits of the rice industry. It is the classic case of the rich getting richer, and the farmer remaining static with his marginal profits from his small farm production.

A third model is the concept of integrating processing and trading with the farm production operations of the farmer. It centers on the active participation of the farmer and the rice-farming village. This has been tried in different scales of capacities, by organizing the farmers into associations or cooperatives, and investing in processing facilities. The farmer participates in processing and trading. The Indonesians are working along these lines with their farmer cooperatives (the BUUD), which are supposed to have their own farm drying units, village storage *lumbong,* and small-scale milling facilities. BULOG, the government rice agency, purchases from these cooperatives for buffer stock and for the needs of the army and government. This model requires strong assistance and guidance from the government until farmers have been taught the virtue of self-reliance. The model also requires a different type of technology, which, rather than being capital intensive, should be labor intensive. For example, the emphasis would be on farm drying and use of local forms of energy such as the rice hull, rather than on central-plant drying with automated controls. And because of the participation of the farmers, there may be greater incentive to producing good quality grain.

There are other models, but in summary, we need an operational model in the postproduction sector that will be viable and grow and flourish in our social, economic, and political environment. We need an operational model that can provide the delivery system, as well as help create a progressive rural community centered on the rice farmer in villages. We are looking for a setting to focus work in developing the technology needed to improve the efficiencies of the postproduction delivery system and minimize losses. The reduction of losses can contribute significantly toward achieving self-sufficiency in rice.

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Discussion

Dr. de Padua's paper presented data on wet season rice and stated that less losses are expected for the dry season crop. In addition, greater losses are expected from higher-moisture crops such as vegetables and fruits because of their high metabolic activity. Rough rice has a longer shelf life (about 8 mo) than either milled rice (1-3 mo) or undermilled rice (1-2 wk). The shorter shelf life of processed rice is caused by lipase activity that induces hydrolytic rancidity of the oil in the outer layer of the rice grains. The surface layer of milled rice has a higher oil content than the rest of the grain endosperm. Parboiling was mentioned as a way of minimizing loss during storage and milling. Processes that combine infrared or hot-sand drying and parboiling of freshly harvested rough rice are economically attractive and give an excellent quality milled rice, without loss of thiamine and riboflavin. Parboiling of steeped rough rice is a way of accelerating aging to improve the texture of the cooked rice by gelatinizing the starch.

In addition to the losses of ricediscussed by Dr. de Padua, actual physical loss or waste by the consumer and the boiled rice given to pets in Philippine households may be as much as 10 g of milled rice per capita daily. Restaurant wastage would be even greater.

Consumers prefer highly milled rice to undermilled rice. In the Philippines, a premium price for highly milled, whole-grain rice is approved only if the rice is enriched with vitamin premix.

Postharvest wastage in noncereal crops, with specific reference to fruits and vegetables

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SOUTHEAST ASIA IS FACED with a great need to produce more and better foods for its ever-increasing population. New directions in national development and an increased awareness of nutrition are now having significant impacts on agriculture. Continuous improvement of genetic varieties, as well as horticultural practices designed to improve the quantity, quality, and nutritive values of crops, are being emphasized by food producers. However, improved postharvest techniques must go hand in hand with such efforts to produce higher-quality, more nutritious crops. Postharvest losses from the farm to the dining table are unnecessarily high and should be reduced to a minimum. Without proper handling of fruits and vegetables after harvest, the efforts and time spent by growers are wasted.

In many tropical countries, postharvest wastage of fruits ranges from 14 to 87%; for vegetables losses may be 22 to 78% (Tables 1 and 2). Losses in perishable commodities occur through shrinkage, sprouting, decay, overripening, mechanical injury, poor trimming, browning, and a high percentage of culls. Postharvest procedures are, therefore, as important as production techniques, especially for highly perishable fruits and vegetables. The whole process from planting to marketing must be a cooperative venture between growers and those who handle the products after harvest.

NUTRIENT CONTENTS OF FRUITS AND VEGETABLES

Both consumers and growers should have a general knowledge of the nutritive values of fruits and vegetables. Information on the nutrient content of food is essential to the serving of well-balanced meals. (The production of fruits and vegetables that are less expensive sources of vital

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Table 1. Postharvest wastage of fruits in the Philippines.

Fruit	Conditions			Wastage (%) due to					Total wastage (%)
	Market or source	Days held	Others	Decay	Over-ripening	Mech. injury	Wt loss	Others	
Avocado	Zambales	6	5 varieties	8–10	5–7	—	1–3	—	14–20
Banana	Tagum, Davao	1	Cavendish	—	—	—	—	15–25[a]	15–25
	Divisoria, Manila	4	Degreened "Saba"	4	4–6	5	3–5	2–4[b]	18–24
	Calamba, Laguna	5	Degreened "Latundan"	3–5	5	5	3–5	5	21–25
Citrus Calamansi	Mindoro-College, Laguna	3		2–4	4–6	14–32	—	24–45[c]	44–87
"Valencia"	Davao-Manila	35[d]	3 shipments	20[e]	5	5–10	5	—	35–40
Lanzones	Los Baños, Laguna	4	From Paete	1–2	2–4	3–4	5	20[f]	31–35
Mango	Carbon, Cebu	4	Full yellow	10–15[g]	5	3–5	—	—	18–25
	Iloilo City	3–5	Full yellow	15–20	5	5	—	—	25–30
Papaya	Divisoria, Manila	3	From Cavite	8–12	2–4	10	—	—	20–26
Pineapple	Cagayan de Oro	Unknown	—	10	5	3	—	—	18
	Calauan, Laguna	4–5	Roadside	8	4–8	—	—	6–8[h]	18–24
Rambutan	College, Laguna	4	From red-ripe	2–4	—	5–8	5–8	20[i]	32–40

[a]Larger or smaller than size requirement for export. [b]Improper handling. [c]Due to oleocellosis. [d]Includes 30-day storage in Manila. [e]Mainly due to improper storage conditions. [f]Due to surface browning. [g]Due to anthracnose. [h]Except calamansi. [i]Due to shriveling.

Table 2. Postharvest wastage of vegetables in the Philippines.

Vegetable	Conditions			Wastage (%) due to					Total wastage (%)
	Market or source	Days held	Others	Decay	Trimming	Mech. damage	Wt. loss	Others	
Snap beans	Baguio Divisoria	2	In sacks	—	—	15	5–8	5[a]	25—28
Cabbage	Baguio-Divisoria-Calamba	4	Open storage	15–20	15–20	10	—	—	40–50
Cauliflower	Baguio College, Laguna	7	Open storage	10	2–4	2–4	5	15[b]	34–38
Corn, sweet	College, Laguna	2	Stored at 10°C	—	—	—	5	50[c]	55
Onions, white	Nueva Ecija Divisoria	150	[d]	15–25	5	2–3	10	15–35[e]	47–78
red	Nueva Ecija Divisoria	240	[d]	10–15	5	2–3	5	5–20[e]	27–48
Potato, white	Baguio College, Laguna	300	Stored at 4°C	5–15	—	2–3	5	10[e]	22–33
Tomato	Lipa	4	Degreened	1–12	—	4–6	2–4	15–20[f]	22–42

[a]Loss of turgor. [b]Change in color of curd. [c]Loss of soluble solids (sweetness). [d]White, stored for 4¼ mo at 1°C; for 2 wk at 27°C. Red, stored 7½ mo at 0°C; for 2 wk at 27°C. [e]Sprouting in storage. [f]Overripening and culls (very small, misshapen, etc.).

nutrients than those now available should also be considered by the growers.)

Table 3 shows the nutrient content of some fruits and vegetables commonly available in the Philippines. It should be noted at once that these

Table 3. Fruits and vegetables rich in one or more nutrients.

Nutrient	Fruits	Vegetables
Protein	tiesa, tamarind, durian	mungo cowpea, lima beans, snap beans, pigeon pea. soybean, chick-pea
Carbohydrates	tamarind, tiesa, durian, banana	white potato, sweet potato, taro sweet corn
Fats	avocado	soybean
Calcium	paho mango, tamarind	horseradish leaves, mustard, amaranth, soybean
Phosphorus	tamarind, durian	mungo snap beans
Iron	strawberry, paho mango, santol	amaranth, mungo, mustard, soybean
Sodium	starapple, muskmelon	swamp cabbage, carrots, mustard
Potassium	calamansi, tamarind	mungo
Vitamin A	pico mango, tiesa, carabao mango, papaya	carrots, swamp cabbage, horseradish leaves bitter gourd leaves
Thiamine	tamarind, durian	pechay, amaranth mustard, soybean
Riboflavin	durian, tamarind, paho mango	horseradish leaves, soybean
Niacin	tiesa. guava, avocado, durian	mushroom cowpea
Ascorbic acid	cashew, guava, strawberry, acerola, calamansi, oranges	horseradish leaves tomatoes sweet pepper bitter gourd leaves, cabbage

are not necessarily the produce desired by the consumers. In practice, little attention is paid to nutritive value; the products most appealing to sight and taste are still the ones preferred.

NUTRIENT LOSS AND ITS CAUSES

The farmer views immediate postharvest losses and wastes primarily in terms of a reduction in the quantity of the food he has to sell, hence in profits. Along with loss in quantity, however, is a reduction in nutrient content. Consider a produce of marketable quality that has undergone the usual postharvest operations of harvesting and handling, transport, storage, and packaging. Even assuming that postharvest wastage is negligible, the loss in nutritive value is still not zero. Nutrients are lost through actual destruction; in addition the marketable commodities themselves undergo certain chemical changes that result in loss of nutrients.

The rate of nutrient loss depends partly on the maturity of fruits and vegetables during harvest and storage. For example, small, immature tomatoes lose more of their reducing sugars than larger, immature ones do. Green, mature tomatoes do not vary much in the amount of reducing sugars, but turning fruits lose much of their sweetness during the storage.

Table 4 shows the cumulative percentage decrease of total sugars in different snap-cowpea lines stored for different lengths of time at high

Table. 4. Cumulative percentage decrease of total sugars in different snap-cowpea lines stored at different temperatures for 1 to 8 days.

Storage temperature	Days (no.) in storage	Decline in total sugars (%) of				
		VC14	VC 15	BS 1	AS	V67-3
82°F	1	52.8	65.8	60.0	51.0	59.6
	2	54.7	81.3	62.8	63.3	80.8
	3	69.8	84.4	70.6	71.4	-
50°F	1	16.0	14.0	23.5	22.5	17.3
	2	34.0	32.8	27.6	32.7	30.0
	3	-	62.5	39.2	36.6	59.6
	4	62.8	71.9	-	40.0	65.4
	6	69.6	75.0	43.1	45.0	71.2
	8	79.2	76.6	54.7	49.0	-

and low temperatures. The rate of loss of total sugars depends on the storage temperature and cowpea variety.

In general, ascorbic acid content decreases rapidly at higher storage temperature for tomatoes, asparagus, pechay, Chinese cabbage, mustard, lemons, oranges, grapefruit, and acerola. It decreases fairly rapidly in sweet potatoes during the first 2 to 3 months of storage, after which it remains at a steady, low level. The average ascorbic acid content in sweet potatoes after storage is about one-half to two-thirds less than that at harvest time.

Free amino acids are also lost rapidly during storage. In peas, free amino acids fall abruptly after 2 days at 68°F, and after 5 days at 43°F, but remain stable at 35°F up to 28 days.

Nutrient loss is not always recognized as important. It depends on what the consumer prefers and hopes to get from the commodity. The ascorbic acid content in potatoes may be lost slowly during storage, but reducing sugars may increase, thus improving flavor. The same phenomenon is observed during storage of some fruits, such as mango and papaya. Loss of acidity in these fruits is accompanied by an increase in sugars, and a sweeter flavor.

In most cases, deterioration in the quality or the sensory appeal of a product also indicates a loss of nutrients. Nutrient loss, however, should not be confused with conversion of a nutrient from one form to another, as in the case of carbohydrates. For tropical fruits an increase in sugars is a normal reaction to the breakdown of polysaccharides. Longer storage precipitates loss of sugars. Sweet corn loses its sweetness rapidly after harvest because of the conversion of sugars to starch. In this case, the amount of carbohydrate remains more or less stable; what has taken place is conversion from one form to another. Starch hydrolysis in bananas results in equal concentrations of glucose and fructose, and a little sucrose. However, all three sugars decrease during prolonged storage.

QUALITY

The desirable characteristics of a fruit or vegetable are dictated by its intended use. Because the main outlet for fruits and vegetables is the fresh food market, the acceptability of the produce is determined by its size, attractiveness, and organoleptic quality. The processor, however, is primarily interested in color, flavor, and texture. In the eyes of both food processors and the public, the criteria for quality of fruits and vegetables are sensory in nature. These criteria may include color, gloss, size, shape, defects, odor, and taste, all evaluated by the consumers' senses.

Color increases the attractiveness of fruits and vegetables and, in most cases, it is used as a maturity index. It is associated with flavor, texture, nutritive value, and wholesomeness. Some characteristics, preferred by buyers because they are attractive, may, fortuitously, also contribute to good nutrition; hence, preference for yellow sweet corn and sweet potatoes helps assure one of Vitamin A requirements.

Size is of major interest to the grower because in certain crops, e.g., pineapple, it is directly proportional to the yield per unit area. Generally, large-size fruits are the most economical, but in some cases consumers prefer medium-size ones for their better taste and texture. The eating quality of vegetables usually decreases with size and maturity, hence small-size produce may be in greater demand than larger ones. The processing industry is more discriminating about the shape and size of fresh produce than is the consumer.

For a product to be acceptable, its texture must conform to what people consider is desirable in a particular food. The physical characteristics sought in one product may be rejected in another. For example, most people want baked white potatoes to be dry and mealy, but expect sweet potatoes to be moist and soft.

Poor quality in fruits and vegetables may be caused by inferior genetic characteristics or unfavorable environmental conditions during growth, for example, the presence of microorganisms and insects not only reduces crop yield, but also changes the color and texture and induces mold and rot.

Deterioration of quality

Some growing areas are particularly suitable for producing fruits and vegetables; therefore, production tends to be concentrated there, where costs are lowest and quality is highest. The time required for harvesting, handling, and transporting produce from field to market, or to storage warehouses and packaging plants, allows tremendous deterioration of quality to occur by the time the produce is offered for sale.

Deterioration starts during harvesting. Many erroneous, inefficient practices aggravate the situation. Knowledge of maturity indices is often inadequate. In most instances, maturity is judged by outward appearances that are often unreliable. Price considerations are usually given more weight than the quality of the produce. If the prevailing market price has risen because the product is scarce, crops are harvested before they reach prime quality. The farmer and his workers may also be indifferent to the condition of the crop after harvest. The only constraint on them is the need to avoid obvious external injury. Workers are often paid according to the quantity of the crop they have picked, which leads to careless harvesting. Infested and defective fruits are picked together with sound ones, thus increasing the chances of the spread of disease and infestation.

The two most important packaging factors affecting food quality are improper packaging materials and unsuitable size of containers. In the Philippines, the bamboo basket called *kaing* is the usual packaging material because it is the cheapest. But it has several disadvantages: its sharp edges often bruise the softer fruits and vegetables during handling operations; the basket is usually round, and so the produce cannot be packed efficiently. Bamboo is a flexible material and the bottom of the basket may break under a heavy load. The baskets are too deep, and thus the produce risks being crushed. In many instances, infested or diseased fruits and vegetables are packed along with sound ones, permitting easy spread of diseases and rot.

Distance in itself does not affect the quality of the produce as much as do the road conditions from field to packinghouse and finally to the market. In developing countries, feeder roads usually connect the vegetable farms and orchards with the highway. Carts, sleds, horses, bullocks, or even people are employed to carry the products either to transportation facilities or to collection points. During transport, the produce is sometimes squeezed into the smallest possible space to avoid making more than one trip from farm to market; this results in bruised and broken skin and poorer quality.

Delay in transport likewise causes losses in quantity and quality. Such delays may be due to accumulation of harvested crops, or to road conditions, especially during the rainy season. Deterioration is caused mostly by overripening, loss of moisture, and, eventually, rotting. If picking time is delayed until transportation is available, the produce may already be overripe or postmature by harvest time. Uncertainties in transport schedules, poor weather, and deferred handling at loading and unloading points are also detrimental to the quality of perishable produce.

Nothing is more appealing in the marketplace than freshly harvested fruits and vegetables. In nonproducing areas, consumers do not have any option but to buy produce that has been stored for several hours or days. Quality is greatly affected by storage temperature, relative humidity, and length of storage time. Each of these conditions affects different kinds of produce in specific ways. To minimize quality losses, the produce should be stored at optimum condition with proper overhead protection, as commodities exposed in the open lose quality through surface evaporation.

POSTHARVEST WASTAGE: APPROACHES TO THE PROBLEM

The problem of postharvest wastage of fruits and vegetables is a complex one, for it includes quality as well as nutrient losses. The solution to this problem involves not only the adoption of proper techniques, but a change in people's attitude.

The established postharvest procedures employed at present in developed and, more especially, in developing countries are far from ideal. Many improvements and innovations are needed, and continuing research is necessary to identify problems and propose possible solutions. Along with concerted efforts to breed more resistant, higher-yielding plant varieties, and to control soil and climate factors insofar as it is possible, techniques for handling the produce after harvest must also be improved. Without all these together, increased availability of high-quality fruits and vegetables is unlikely.

Growers, handlers, and consumers must be convinced that postharvest procedures are as important as production techniques. High yield per unit area is not enough if crops go to waste after harvest because of improper handling. To reiterate, the whole process, from planting to consuming, must be a cooperative undertaking between the growers and those who handle the products after harvest. Postharvest technology from farm to market must be considered a single system. Success in maintaining the harvest-fresh quality of produce demands control at each step, and each step depends on the previous one. Handling procedures from harvest until the produce reaches the consumers are chains of interdependent activities. (Of course, if the initial quality of the product is poor, no postharvest treatment can improve it.)

Public acceptance and approval of the establishment of government-sponsored wholesale markets and cold-storage facilities are needed. The erection of cold-storage plants in areas accessible to farmers must be accompanied by a sustained information campaign on their use and benefits. Encouragement in the form of low rental rates for storage space and immediate payment after the sale of products must be given to farmers.

Small landholders are sometimes faced with lack of capital and poor return on their investments. Cooperatives have done wonders in certain countries, but only where they are effectively run and where the members are aware of their responsibilities and benefits. Members of a cooperative have better bargaining powers, can borrow needed capital, and are more certain of selling their produce at a reasonable profit, facts which can motivate producers to improve the quality of their produce.

A continuing problem in developing countries is the low educational level of farmers and their reluctance in accepting new farming methods. Educating farmers to understand better, and to utilize appropriate modern techniques of food production and postharvest operations is vital, but it may take years.

Improvements and innovations in agriculture initially cost money. If, however, people's buying power can be increased by economic progress, they will be more willing to accept price rises necessitated by improvements in postharvest handling of fruits and vegetables.

Postharvest losses: workshop summary

The workshop discussion emphasized the nutrient losses in vegetables, fruits, legumes, and cereals other than rice.

The discussion sought to identify which nutrients are lost, the causes of losses and ways of preventing or correcting such nutrient losses; and to recommend what agriculturists and food scientists might contribute to solve the problems of these losses. The following conclusions were reached and recommendations made.

NUTRIENT LOSSES AND THEIR CAUSES

1. The most important and significant loss is in food quantity (hence the physical availability of nutrients) because of improper operations as well as pest infestation during reaping, bundling, storage, transport, marketing, etc. It is estimated that the total losses amount to 10-37% of rice actually grown and perhaps as much as 50% for vegetables and fruits.
2. Nutrient losses are also caused by improper precooking and cooking practices, e.g., overcooking of green leafy vegetables that results in loss of water-soluble, heat-labile vitamins.
3. Nutrient losses occur during metabolism as a result of inefficient nutrient combinations, i.e., an unbalanced diet.
4. Nutrient losses or toxicity, or both, are associated with the presence of molds in grains, oilseed meals, and roots and tubers.

PREVENTION AND CORRECTION OF NUTRIENT LOSSES

1. Adequate marketing information should be systematically provided to farmers to ensure appropriate supply, especially of vegetables and fruits.
2. Increased home-farm or community processing of certain fruits and vegetables by such traditional methods of preservation as drying, pickling, etc., should be encouraged.
3. Nutrition education for all classes and ages should be promoted, and proper food-handling and preparation methods taught to ensure efficiency in utilizing the available food supply.
4. Farmers should be educated on the effects of moisture content and bruises or injury to nuts and oilseeds in relation to insect and fungal infestation, particularly by aflatoxin.

RECOMMENDED ACTION BY AGRICULTURISTS AND FOOD SCIENTISTS

1. A systematic survey should be conducted in the countries of Southeast Asia to determine the nature and actual extent of physical, as well as nutrient, losses of the various grains, green leafy vegetables, fruits, legumes, tubers, and Vitamin C-rich foods, for which very limited information is available. Studies on specific postharvest handling and transport practices in relation to the vitamin losses sustained by agricultural products should also be conducted.
2. Manpower should be trained to use the available postharvest technology, especially for fruits and vegetables.
3. Experts should explore the feasibility of establishing small-scale food-processing centers on farms, using village technology and concentrating on canning and the use of preservatives. This is one practical way of a) minimizing losses of fruits, vegetables, and legumes during transit to urban areas, and b) making these foods available throughout the year.
4. The feasibility of raising small domestic animals that would consume the damaged and deteriorated cereals, legumes, fruits, vegetables, and oilseeds should be considered.
5. The peculiar physical characteristics of some fruits and vegetables that will affect handling techniques should be considered in plant breeding research.
6. Crop protection research and application, aimed at reducing losses due to pests of all kinds, should be intensified.
7. Research on the processing of various fruits and vegetables of high nutritive value, especially for low-income populations in rural communities, should be carried out.
8. Special efforts must be made to establish more efficient and effective collaboration among agriculturists, food scientists, and nutritionists.

Nutrition goals for agriculture

SOEKIRMAN

DURING THE PAST DECADE, significant advances were made in augmenting food grain production. In Indonesia, rice production from 1967 to 1971 increased from 11.7 million t to over 14 million t, or at an annual rate of increase of 4.8%. Increase yields of rice and wheat in several Asian countries were brought about by the new food grain production technology developed for the Green Revolution. Although there is no automatic connection between increased food production and consumption, the increase in grain production did maintain or improve the per capita availability of calories and protein.

Despite the obvious achievements of the Green Revolution as ". . .a greater force for change than any technology or ideology ever introduced in the poor countries," (Brown 1976) its success depends too heavily on agricultural inputs that are beyond the purchasing power of poor farmers. Since 1973, after the setback in world food grain production, the Green Revolution has been an "opportunity lost" (Brown and Eckholm 1974). Small farmers, whose families are especially vulnerable to malnutrition, have hardly benefited from the new high yielding varieties of grain. Norman Borlaug, the father of the Green Revolution, has admitted that, "if we can't get the Green Revolution to the little guy, there is no revolution" (Anderson Jr. 1976).

There are three basic questions with respect to the nutrition goals, which agriculture should ask itself. First, how much food needs to be grown to improve nutrition? This quantitative problem is largely the concern of agricultural planners. The second question is, how do you make the Green Revolution relevant to small farmers? And the third is, how can national nutrition goals be incorporated into agricultural development planning?

This paper discusses these three issues, drawing heavily on experiences in Indonesia.

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THE REQUIREMENTS OF HUMAN NUTRITION

Dispute on the adequacy of the Recommended Dietary Allowance (RDA) for protein and energy has gone on for some time among scientists. Sukhatme (1974) has argued that there is no evidence of any protein gap. He notes:

> A new interpretation has been placed on the meaning of recommended intake by the FAO/WHO Expert Committee on Nutrition which enables nutrition experts to establish the size of the protein gap and the massive dimension of the problems posed by it. The interpretation is that an individual eating below the recommended level (i.e., average requirement plus twice the standard deviation), while not necessarily malnourished, runs the risk of developing protein deficiency and that the risk increases as the intake falls below the recommended level.

In his analysis of this new interpretation, Sukhatme (1974) denies the validity of the assumption. He concludes:

> We find that the incidence of simple protein deficiency is of the order of 10% compared to over 50% which one would obtain based on the interpretation of the FAO/WHO Expert Committee. Clearly the incidence of simple protein deficiency is grossly exaggerated in the current writings on the subject.

The fact that the FAO/WHO energy/protein recommended allowance has changed three times since the first recommendation in 1955 demonstrates that nutrition scientists still have no absolute knowledge in this field. In one of his papers, Scrimshaw (1976) suggests that the 1973 FAO/WHO recommendation on energy and protein requirements is already in need of reexamination. He states:

> As for human protein requirements, the pendulum is still swinging because our knowledge is so incomplete. In fact, for all nutrients, our knowledge of precise human requirements and the interrelations among them is far more fragmentary and tentative than generally realized.

In Indonesia, an individual's average daily calories and protein requirement was set at 2,100 calories and 55 g of protein. The requirement was based on the adaptation of the 1965 FAO/WHO Protein Requirement Report (WHO 1965), and was formulated at the Joint Workshop on Food held in 1968 in Jakarta by the Indonesian Institute of Science and the US National Academy of Sciences. The "translation" of this nutrient requirement into a "menu pattern" has been used for food production purpose since 1969 (Table 1). This menu pattern may, however,

Table 1. Food supply compared with requirements in Indonesia, 1974.

Foods	Requirements[a] (kg/capita per year)	Supply (1974)[b] (kg/capita per year)
Cereals	1431	152.1
Rice	120 5	121.5
Maize	22 6	25.7
Wheat	-	4.9
Tubers	74.6	81.0
Cassava	-	59.5
Sweet potato	-	17.4
Sago	-	4.1
Pulses	16.6	5.9
Groundnut	-	1.8
Soybean	-	4.1
Fruits and Vegetables	98.5	54.1
Fruits	-	36.3
Banana	-	20.8
Pineapple	-	1.0
Others	-	14.5
Vegetables	-	17.9
Potato	-	1.2
Others	-	16.7

[a] Workshop on Food, Indonesia, 1968. [b] Food supply analysis, 1974, Bureau of Statistics, Jakarta.

put too much emphasis on rice. Thus, in a statement before the participants in the 1976 Symposium on Food and Nutrition, the Director General of Food Crops of the Indonesian Ministry of Agriculture commented that agricultural planners had asserted that nutritionists were among those responsible for the ever-increasing demand for rice in Indonesia during the past decade; but the fact is that, nutritionists in Indonesia had, for a long time, been giving the warning "not by rice alone," to remind people and policy makers that a "rice policy" could be detrimental to the nutritional status of the poor farmers in Java. Twenty-four per cent of the calorie and 30% of the protein intakes of the rural poor are derived from corn, while for the rural middle class, only 13% of calories and protein together originate from corn (Sajogyo 1974).

The fact is that the "menu pattern" has been applied in different ways. After the "menu pattern" was formulated, no system was established to enable the agricultural planners and nutritionists to communicate periodically.

The third Indonesian Five-Year Development Plan (1979–84) is to begin in April 1979. As of this writing, no decision based on scientific data has been taken on whether to follow the low calorie and protein requirement recommended by FAO/WHO in 1973, or to stay with the formulation of the

1968 Workshop on Food.[1] In addition to the need to set such a policy, there is a need to translate nutrient requirements into Regional Consumption Patterns to diversify the food-production policy to reflect the eating habits of people in different regions. In summary, the uncertainty about nutrient requirements could hinder the efforts to link nutrition goals with agricultural development planning.

THE GREEN REVOLUTION AND SMALL FARMERS

The Green Revolution has, so far, been largely a wheat and rice revolution. There is no doubt that the economic benefit from the Green Revolution has generally accrued to the large farmers and to farmers with an established irrigation system. In Indonesia, the Mass Guidance Program (BIMAS) for small rice farms of 1 ha is able to increase the annual income by 40 to 60%. The head of the Indonesian delegation to the 13th Food and Agriculture Organization Regional Conference for Asia and the Far East, held in Manila in August 1976, reported that farmers growing high yielding varieties earn a 30 to 45% higher income than those growing local, traditional varieties. In addition, income in areas where Green Revolution rice strains have been adopted has become more equitably distributed among farmers. It should be kept in mind that these figures were derived from a study conducted on paddy farms with adequate irrigation facilities and an efficient seed and input distribution system (Soejono 1976).

What about the nonrice-growing and dryland farmers, the small farmers with less than 0.5 ha, and the landless laborers? Most of these individuals belong to the lower 40% of the socioeconomic scale. They are also the most vulnerable group in terms of nutrition. In the 1975 study on poverty, unemployment, and development policy in Kerala, India (UN Department of Economics and Social Affairs 1975), the magnitude of undernutrition was found to be 94% in the lowest income group, and only 26% in the highest income group. In Indonesia, more than 40% of the population live below the poverty line and a substantial gap in calorie and protein intake exists between the poor and the affluent. It has been reported that the poor consume 30 to 40% fewer calories and 50% less protein than the more well-to-do (Sajogyo 1974).

The Green Revolution has passed by the very groups most vulnerable to undernutrition. Many ways are being planned or tested to expand the scope of the Green Revolution to meet the demands of the poor. Research and training being conducted at the international and national agricultural research and training centers scattered all over the world (Table 2) should be accelerated so that benefits will be available as soon

[1]Sajogyo was the first to adopt the 1973 FAO/WHO recommendation of 1,900 calories and 40 g protein per capita per day, instead of 2,100 calories and 55 g of protein. Recently, Lie Goan Hong (1976) proposed a theoretical "Minimum Energy and Protein Requirement" of 1,850 calories and 41.7 g of protein per capita per day.

Table 2. International agricultural research and training centers.[a]

Location	Institution[b]	Field of research
Philippines	IRRI	Rice multiple cropping
Mexico	CIMMYT	Wheat corn
Colombia	CIAT	Cassava field bean rice corn swine cattle
Nigeria	IITA	Yam cowpea rice corn sorghum, millet, soybean cassava, sweet potato
Taiwan	AVDRC	Soybean tomato mung bean Chinese cabbage, sweet potato white potato
Peru	CIP	White potato
India	ICRISAT	Sorghum, millet peanut, chick-pea, pigeon pea
Kenya	ILRAD	Animal disease
Ethiopia	ILCA	Livestock
Liberia	WARDA	Rice
Rome	IBPGR	Collection and exchange of plant genetic materials
Cairo, Egypt	ICARDA	Crop Improvement, durum wheat barley lentils broad beans. Farming systems in war and cold winter climates primarily sheep

[a]Adapted from the Consultative Group on International Agricultural Research (CGIAR). [b]Institutions are named in order of establishment International Rice Research Institute International Maize and Wheat Improvement Center International Center for Tropical Agriculture International Institute of Tropical Agriculture. As an Vegetable Research and Development Center, International Potato Center, International ora Crops Research Institute for the Semi-and Tropics, International laboratory for Research on Animal Diseases International Livestock Center for Africa, West African Rice Development Association, International Board lor Plant Genetic Resources and International Centre for Agricultural Research in the Dry Areas

as possible, and the results of research should be disseminated more effectively to appropriate countries. For example, the International Rice Research Institute (IRRI) has helped Indonesia, not only with rice technology, but also in improving the already existing multiple-cropping system in this country (McIntosh and Effendi 1976).

In addition to technology enabling small farmers to benefit from the Green Revolution, a broader base of land ownership is necessary. In Indonesia, an agricultural census in 1963 indicated that, of 10 million households in Java, only 7.9 million have more than 0.1 ha of land. Of the latter, 3.8 million have, on the average, 1.2 ha, and 4.1 million own 0.2 ha. Sajogyo (1976) has proposed that the government buy the land of farmers holding less than 0.2 ha and lend it back to them, to be cultivated more efficiently and productively through a farm labor cooperative. He argues that this is the only effective way of helping the small farmers.

Not only should food production be increased, but more attention should be paid to postharvest technology at the village level to reduce waste and loss of grain. In areas where there is a positive balance in food supply (quantitatively and qualitatively), nutrition goals for agriculture should be directed more toward trade policy, food-storage facilities, handling, processing, etc., than toward food production. In short, if the small landowner is ever to benefit from the Green Revolution, it must be adapted to meet his needs and not just those of the large landowner.

THE DECISION-MAKING PROCESS

To appraise nutrition programs, Montgomery (1976) has formulated three approaches. The first is to examine issues of nutrition policy by identifying the principals who set the policy and who took over at different stages; the second is to look at the targets or specific groups at which the policies are aimed; and the third is to analyze the nature of policy formation and to examine alternatives. Thus, in directing nutrition goals for agriculture, it is important to first identify those who make the decisions. In Indonesia, for instance, the first and most important persons who must be sold on a policy are the members of the People's Consultative Assembly (MPR), the highest legislative organ in Indonesia. Once the basic policy of linking nutrition goals to agricultural development is included in the State Policy for National Development and approved by the MPR, a strong government commitment will follow, provided people who understand the problems related to the issue are involved.

Most nutritionists and academicians are usually satisfied with published proceedings of seminars and workshops, but they often neglect to follow up the exercise. They fail to communicate with the people who would translate their technical recommendations into policy, planning, and programming. Nutrition goals for agriculture should have specific beneficiaries, like small farmers and landless laborers. The approach considering the target groups is usually neglected.

CONCLUSIONS

There are four basic concerns in formulating nutrition goals for agriculture:

1. The controversy about the RDA, especially for protein, has to be resolved. More research is needed to understand better the nature of calorie and protein deficiencies in developing countries. This is, of course, related to reevaluation of the calorie and protein requirement used as the standard.

2. Research being conducted in various agricultural research centers such as IRRI, AVRDC, and ICRISAT has to be defined more clearly so that their objectives can be made more relevant to the needs of small farmers who cannot afford the food grain technology of the Green Revolution. Technology should be more quickly utilizable in the community. In areas with a positive balance in the nutrient supply, more attention should be given to postharvest technology as the village level. In addition, an appropriate trade policy is needed to strengthen the link between nutrition

goals and agricultural advancement. To help small farmers with less than 0.2 ha of land, a type of land reform coupled with the establishment of small-farm labor cooperatives, as suggested by Sajogyo (1976) for Indonesia, is worthy of consideration.

3. A more effective communication system between the technical experts dealing with nutrition and the national policy makers should be arranged so that recommendations that are scientifically formulated in research centers can be followed by action.

4. Any attempt to correlate nutrition goals with agricultural development will be meaningful only if it helps more small farmers and landless laborers in the developing countries achieve better nutrition.

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Discussion

1. A study by the International Maize and Wheat Improvement Centre found that small farmers lag behind larger farmers in accepting new varieties of rice for sowing.

2. There is a great need fordataon the protein requirements of populations of developing countries, populations that subsist on local diets. Most of the data available thus far have come from developed countries.

3. The cropping systems program of the IRRI was also cited as a means of obtaining protective foods that will supplement the regional staple food – rice.

Nutrition goals for sector planning and national planning

FLORENTINO S. SOLON

THE PROBLEM OF MALNUTRITION IN DEVELOPING COUNTRIES

The problem of malnutrition in developing countries has reached critical proportions and can no longer be ignored in the formulation of national development goals. Nutrition, not itself a "sector," has a multisectoral nature, and is the concern of many ministries and jurisdictions (agriculture, health, education, etc.). It involves interrelated determinants of human progress. On one hand, proper nutrition may be a precondition to the advancement of other factors and a stimulus to many forms of production; on the other, adequate nutrition can be the result of the interplay of these other factors and productive forces. Poverty, for instance, is often considered an underlying cause of malnutrition, but an antipoverty campaign is not necessarily the most effective solution to child malnutrition. Furthermore, what may at first glance appear to be a nutrition problem may, on closer analysis, turn out to be primarily the problem of a specific economic group or social subdivision.

Among the major determinants of nutritional status in developing countries is the world food situation which, in turn, is affected by various factors. Adverse weather conditions, the oil crisis, inflationary trends, and natural disasters have contributed to the current worldwide food shortage, a problem further compounded by rapid population growth. According to United Nations projections, the population of developing countries is expected to increase (from 2.8 billion in 1973) to 3.7 billion in 1985, and to reach 5 billion by the year 2000, despite the anticipated reduction in population growth rates in these countries from 2.5%/year at present to 2.3%/year in 1985, and to 2.0% by 2000. So precarious is the world food situation that the United Nations has called for an annual world food conference to discuss proposed solutions to the crisis. The United Nations World Food Conference held in November 1974

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estimated the underfed population at close to 500 million, most of whom are in countries suffering from economic and social deprivations.

Other factors affecting nutritional status, such as increased income and more equitable distribution, literacy, beliefs about food and consumption practices, food technology, and sanitation, straddle a broad gamut of sectoral responsibilities and functions, each of which lays a strong claim on national attention. In many instances, some of these factors are beyond the reach of nutrition leaders; in other cases, policy makers in these fields do not specifically incorporate consideration of nutrition into their planning equations. This makes for a weak, fragmented, and disorganized response to the malnutrition problem that, in developing countries, has wide-ranging implications. There is a need for integrated, comprehensive, and far-reaching efforts to respond to the situation. The need is for nutrition planning, which is now a characteristic feature of developing countries.

The history of the fight against malnutrition displays three political models. One is that of Western Europe and North America, where undernutrition has been substantially eliminated without conscious effort, but rather through the sheer force of economic development, relying on unplanned, evolutionary processes that took a long time to complete.

The second model is that of the Communist countries, which have also substantially eradicated malnutrition, in a shorter period of time, but again in an unplanned manner, through a revolutionary process that has transformed entire societies.

The third model is that of the Third World, which chooses neither the evolutionary nor the revolutionary process, but has adopted nutrition planning as an immediate and explicit response to an urgent problem. In developing countries, nutrition planning is a short-cut approach to the solution of the malnutrition problem. It recognizes the close relationship between malnutrition and socioeconomic forces, and its goal is to place overall development objectives in their proper perspective, with improved nutrition as an integral part of national development.

NUTRITION GOALS IN ECONOMIC PLANNING

Malnutrition is both a cause and effect of economic underdevelopment. In developing countries, where the poor spend a high proportion of their income on food – as much as 80% of the family budget — there is clearly a beneficial relationship between income increase and nutrition. On the other hand, a national increase in per capita income does not necessarily mean an increase that is large or rapid enough to be nutritionally significant.

Incomes of many of the nutritionally needy are not rising, or are barely rising. From 1960 to 1970, per capita incomes in countries containing two-thirds of the world's population grew at an average of only 1.5% yearly. This average, however, does not give a true picture. The income distribution in some countries is such that the poorer segments of the population received even less than the average share. Income improvements come at a very slow rate. In India, for instance, one-third of the families would need at least twice their current incomes to obtain adequate diets by means of increased earnings alone. This means that if the per capita real income in India is optimistically assumed to increase by 3% a year, it would take about 25 years before the lowest third of India's population could afford a minimum diet. It has been calculated that if current distribution trends continue and the annual population growth rate stays at 2% in countries where populations have an average annual per capita income of US$100, there has to bean eightfold increase in income so that everyone can afford adequate amounts of animal protein. At this rate of income increase, it would take a hundred years for such populations to be economically capable of purchasing an adequate diet.

In the Philippines, a 1971 survey showed that the lower 50% of income recipients accounted for only 21.6% of the total income (Philippines, NEDA 1974-77). Thus, 50.9% of families had incomes below US$400 a year. In the Greater Manila area, only about 24.2% of the families had incomes sufficient to meet nutrient requirements. In the other urban areas, only about 43.6% of the families could afford an adequate diet. In the rural areas, only 19.7% of the families could purchase the least-cost foods to meet their nutrient needs. Obviously, a fundamental economic objective, closely linked to nutrition goals, is an increase in, and more equitable distribution of, income.

Because the Philippine economy is based largely on agriculture, the major thrusts of economic programs have been mainly in this area. Thus, the Agrarian Reform Program is being stressed, and strong incentives in the form of loans, price subsidies, and technical support are provided to farmers.

Present efforts to develop manufacturing industries, trade, and a market infrastructure not only provide employment, but also accelerate economic growth. Encouragement of small-scale industries, including cottage industries, has done much to improve export earnings and increase family income. All these efforts significantly affect nutritional status.

In the process of maximizing the contribution of domestic output to export earnings, however, nutritional consequences may not be favored if imports do not benefit malnourished families, or if the exports create heavy pressure on domestic food prices. Additional food exports do not automatically generate nutritionally equivalent food imports. For instance, an improved world market for soybeans can reduce their availability and, thus, consumption in soy-producing countries. A better alternative may be export of expensive, high-quality foods and import of a larger but cheaper supply of nutritious food. Among other things, improvement in the food distribution and marketing systems, better methods of minimizing food wastage, and wider application of processing techniques suitable for farm households would also mean more food for the poor.

Investment in human capital is also considered a major factor in economic growth. The cost of improving a worker's nutritional state to prevent his incapacitation can be compared with his potential future income. The costs of improved nutrition can be measured in terms of less absenteeism, greater efficiency, and longer working life. Statistics show that it is cheaper to prevent malnutrition than to cure it.

For economic planning, therefore, the factors of production and consumption should be viewed in terms of their nutritional implications. This will require resolution of the alleged conflict between welfare and growth. Full appreciation of nutrition goals, in terms of increased nutrient availability and consumption, is essential to the proper formulation and implementation of economic development goals.

Briefly, the goals for nutrition in economic planning will be:

1. to maximize economic growth, particularly in depressed areas;
2. to promote exports and imports of products that will enhance domestic food availability and consumption;
3. to maximize availability of food through proper economic policies and incentives directed toward improving food conservation, distribution, and processing;
4. to promote equitable distribution of income and wealth;
5. to maintain an acceptable level of price stability, particularly for basic commodities; and
6. to promote employment through training in skills to tap the labor potential, particularly in areas where malnutrition prevails.

NUTRITION GOALS IN AGRICULTURAL PLANNING

In a nation's economy, its agriculture obviously has a strong influence on the nutritional status of its citizens. Among other things, developing countries typically show a heavy reliance on cereals as a source of nutrients. Thus, the development of high yielding varieties of rice and other cereals was particularly beneficial to Asian nations. Much work is currently underway not only to increase yields, but to improve the nutritional quality of the grains. In other agricultural areas, notably vegetable production, and livestock and poultry raising, growth has also been encouraging.

In the Philippines, the Food Balance Sheet for 1973 showed that the country's supply of a number of foods–cereals, roots and tubers, sugar and syrups, fish, meat, and poultry—surpassed the recommended sufficiency level (Philippines, NEDA 1973). The supply of other foods, however, was rather low. For example, the supply of fruits and vegetables was only 66.6% sufficient; fats and oils, 43%; milk, 43.9%; and eggs, 63.1%. The daily per capita caloric supply (2,109 calories), which came mainly from cereals, was 105.4% sufficient. The per capita protein supply (54.4 g), one-third of which came from animal sources, was also sufficient (112.1%) compared with recommended allowances. On the other hand, the per capita fat supply (31.2 g) was grossly deficient, contributing only 13.3% of the calorie supply.

Agricultural self-sufficiency, however, is not synonymous with nutritional self-sufficiency. Increases in food production do not necessarily fill nutritional needs. A Philippine dietary survey of some 680 randomly selected households in Luzon and Metropolitan Manila revealed that, comparing per capita food consumption with recommended allowances, only cereals and "other fruits and vegetables," among the various food groups, were eaten in the recommended amounts (Philippines, FNRI 1974). Consumption of green leafy vegetables and dried beans and nuts, for example, was very low (29.1% and 43.8%, respectively, of the recommended daily amount).

Translating these food intakes into nutrient intakes shows that the average diet was deficient in calories (only 1,823 calories per person, or 92.2% of the recommended level), although the protein intake apparently was adequate (49.2 g per person, or 100.6% of the recommended level). Riboflavin and vitamin A requirements were the least adequately met, with intakes at only two-thirds of the recommendations.

On a national scale, the amount of food available in the Philippines would supply more than the recommended 2,000 calories per capita per day, but the average daily intake is only 1,700 calories. Therefore, statistically, some 15% of the available calories are lost at home, in the marketplace, or in the course of delivery to the consumer,

These data represent only national averages. Because high-income households eat 25 to 35% more food per person than low-income households do, it is probable that the food-energy deficit in low-income families is as much as 25 to 30%. Thus, available food supply should be at least 15% higher in food energy than what the recommended daily intake calls for.

Production levels, however, are not likely to increase without a corresponding increase in market demand which, in turn, will depend on the improvement of income or purchasing power of low-income families. As 70% of Filipino families live in rural areas, one logical way of improving income and diet is through home gardening.

The average Filipino family is composed of six members. At 2,000 calories per person as the average daily food energy requirement, about

12,000 calories per day are needed to meet a family's nutritional requirements. To supplement its supply of food energy, a family might start with a 10-m^2 garden, probably the smallest useful plot for attempting food production. Vegetable-producing beds could be single beds 1 m wide and 10 m long, or double ones 1 m wide and 5 m long. Root crops, especially sweet potatoes, seem the best for a do-it-yourself project to increase a family's available food energy. Dry beans, such as mecan (cowpeas) or mongo, from 10 m^2 give about the same food energy daily as cereal grains that can be grown on an equal area provide; vegetables as a group are about 25 to 30% lower in food-energy yields than cereals or dry legumes. Leafy vegetables are generally the lowest in food-energy yield, root crops and dry legumes the highest. Leguminous pods and other pulpy vegetables are intermediate.

A survey in Cebu indicated that the average land available for home gardens among rural families is 20 m^2. A combination of sweet potatoes and legumes, raised on a plot this size, could supply 300 calories per person per day (family of six) if the plot were continuously and intensively cultivated (Binamira and Solon, unpubl.) However, a 20-m^2 garden can supply only about 50% of the 15% food energy deficit for small families of two or three members, and only 10% for large families. A very large family would need nearly 200 m^2 of garden area to produce the food energy required to correct the average national 15% deficit. Because large families are likely to have low incomes, and their actual deficits may be as high as 25 to 30%, gardens of 350 to 400 m^2 would be needed to correct the energy deficiency. On the whole, home gardens of 200 m^2 or more are needed if any significant impact on food energy deficiency is to be achieved in this way.

Production of milk and poultry, both of which are inadequate, should also be increased. Families should be encouraged to raise livestock as a means of increasing their own and the communtiy's food supply as well as raising their family income. The Bureau of Animal Industry and the Bureau of Agricultural Extension can do much in this regard.

The per capita fat supply in the Philippines is grossly insufficient, as shown by dietary surveys that reveal inadequate caloric intake because of the lack of dietary fat. Vitamin A deficiency has been found prevalent, an indirect result of low fat intake.

Between 1978 and 1982, the food supply in the Philippines is expected to increase by 12%, according to projections of the National Food and Agriculture Council. However, the Council's preliminary forecasts of the demand for food shows an increase of only 6% (or 50% of available food supply), which will, however, mean only a modest improvement in the nation's nutrition. Additional measures, such as higher incomes, control of prices, and the promotion of nutrition education, are needed to stimulate food demand.

However, if the increase in agricultural production is consumed mainly by already well-nourished people, the net nutritional gain to the truly needy will be negligible. Likewise, if increased production favors the large producers who displace small farmers, the latter's reduced food consumption will be the opposite of what national planners desire. Similarly, a profit-oriented shift to nonfood cash crops will adversely affect the poor.

In agricultural planning, the nutrition goals should be the following:

1. To increase food production selectively to meet nutritional requirements. This involves setting specific targets, with emphasis on those foods which are scarce in the daily diets of the general population, i.e., oil, fruits, vegetables, meat, milk, and eggs in the Philippines. Another desirable goal would be to increase supplies of calories and protein beyond recommended levels to alleviate, in part, the inadequate supply among the poorer segments of the population.
2. To supply through effective distribution the largest possible number of consumers with nutritious foods, particularly those lacking in the diets of the poor;
3. To increase the supply of indigenous foods from home, school, and community gardens to help meet domestic demand, and to promote poultry- and livestock-raising projects among families;
4. To support research for the development of higher-yielding cereal varieties of good nutritional quality, as well as research on how to increase the supply of other food sources; and
5. To develop a village-level technology for proper processing of food and for storage of food surpluses.

NUTRITION GOALS IN HEALTH PLANNING

Malnutrition is responsible for major health problems. It causes retardation of physical growth and mental development, and often precipitates acute infections such as gastroenteritis, bronchitis, and other febrile illnesses.

Malnutrition is the leading single contributor to child mortality in the developing countries. It also causes minor childhood diseases, such as respiratory and gastrointestinal infections, to become killers. Measles, for instance, is especially deadly among malnourished children. This was documented in Guatemala in 1965, when the death rate from measles was more than a thousand times greater than that in the United States.

In the survivors, malnutrition exacted a less visible and less measurable toll. The World Health Organization has stated, however, that on the average, 3% of children under five in low-income countries suffer from severe protein-calorie malnutrition. About 25% are estimated to be suffering from moderate malnutrition, and 40-45% from mild malnutrition (Berg 1973).

In many developing countries, it appears that the most important nutritional problems are protein-energy malnutrition (PEM), vitamin A deficiency, iron deficiency anemia, goiter, and B vitamin (especially riboflavin) deficiency.

As of July 1976, results of the nationwide weight survey in the Philippines, known as Operation Timbang, showed that 77.9% of all preschool children weighed were suffering from some degree of PEM: 47.3% were slightly (first degree) malnourished, 24.8% were moderately (second degree) malnourished, and 5.8% were severely (third degree) malnourished (Philippines, Department of Health 1976).

Extensive studies in Cebu Province of 1,715 children 1 to 16 years of age showed that the prevalence of xerophthalmia was 6.4% by clinical criteria, 58% by biochemical criteria, and 3.8% by combined clinical and biochemical criteria (Solon et al 1972). It has been repeatedly confirmed that iron deficiency anemia is highly prevalent among Filipinos, especially in infants and preschool children below 4 years of age, and among pregnant women.

According to Food and Nutrition Research Institute surveys, endemic goiter in the Philippines has a prevalence rate of 4% for the general population, and 12 and 8%, respectively, among pregnant and nursing women.

The Philippine health status is satisfactory by conventional standards, but it is far from ideal because communicable diseases are still uncontrolled and infant mortality rate is high (although this has steadily declined during the past decade).

The availability of health services obviously has a direct influence on the health status of the population. The Philippines has a national ratio of 1.28 hospital beds per 1,000 persons. However, some provinces have ratios of 0.18 and 0.22 bed per 1,000, indicative of maldistribution, as well as inadequacy of health facilities.

The Philippine population is growing at a rate of 2.86% per year. Out of an estimated total population of about 41 million in 1975, 21.6% (or about 9 million) were preschool children and another 21.7% were school children 7 to 14 years old. The 1975 estimate also had 1.7 million pregnant women and about as many nursing women. The average family size was 5.98. Assuming no more than two preschoolers per family, a minimum of 4.5 million families out of a total of 7 million would havepreschool children.

The adverse effect of large family size on the family's nutrition is supported by the findings of different Philippine surveys, which show that as the number of household members increases, average diet ratings become lower (Philippines, FNRI 1958-69). It has been observed that when increase in family size comes with shorter intervals between births, the next to the youngest child is most likely to become malnourished.

Thus, the nutrition goals in health planning are:

1. To reduce the prevalence of total third- and second-degree malnutrition among preschool (0-6 years) children by a specified degree over a specific period of time;
2. To increase the proportion of preschool children with normal weight for age;
3. To reduce the prevalence of anemia in pregnant women and nursing mothers, and of vitamin A deficiency and goiter in endemic areas, through identification followed by implementation of preventive and curative measures;
4. To increase the average per capita consumption of calories and fat through proper food supplementation, and to concentrate these increases in target households (those with a high prevalence of second- and third-degree malnutrition, and low-income groups in priority or depressed areas), with emphasis on children with second-and third-degree malnutrition, as well as on pregnant and nursing women;
5. To prevent and control communicable diseases such as measles, pertussis, and diarrhea, which are usually associated with malnutrition;
6. To prevent and treat parasitism, particularly hookworms, through environmental sanitation;
7. To increase the manpower in the health services with professionals trained to identify and treat malnutrition:
8. To intensify health and nutrition education;
9. To expand health facilities, especially wards for malnutrition, and "nutrihuts" for the rehabilitation of severely malnourished children; and
10. To attain and maintain an acceptable rate of population growth through the promotion of family planning.

NUTRITION GOALS IN PLANNING SOCIAL DEVELOPMENT

In addition to causing purely economic losses, malnutrition prevents its victims from enjoying such sources of human satisfaction as nature, love relationships, friends, good talk, and children. These fundamental sources of well-being are not marketable or quantifiable. Even less quantifiable is the loss to society of potentially outstanding individuals, the casualties of malnutrition, who could otherwise be leaders in tomorrow's civilization.

Increased family income with corresponding improvement of dietary quality is no assurance of benefit to the more vulnerable members of the family: the young child and the pregnant or lactating women. Surveys in Central America, Colombia, Ghana, India, Ivory Coast, Nigeria, and Tunisia show that higher income levels may allow older family members to have satisfactory diets, but children's diets remain 20 to 30% inadequate. This is sometimes due to restrictive beliefs about food and eating practices. In parts of Malaysia and Indonesia, for example, fish is not fed to children because it is believed to cause worms, bad eyes, or skin disease. Eggs are said to cause jaundice and swelling in children in parts of India, indigestion in Lebanon and Syria, and mental retardation in parts of East Africa.

Similar beliefs pertain to pregnant and nursing women. In most Asian countries, women deliberately eat less during pregnancy to have smaller babies and easier deliveries. Malay women are known to restrict their diets severely for 40 days after delivery. Many Indonesian women eat less after childbirth because they think doing so will help them regain their figures more rapidly. In a number of Asian countries, diet containing animal proteins is believed to make the breast milk of nursing mothers toxic; eggs supposedly lead to hemorrhage, and fish is also avoided. A Philippine study shows that 91.4% of mothers surveyed still believe that worms in children are caused by eating fish; 81.4% believe that condensed milk is the best canned milk for infant feeding; and 87.1 % claim that chicken and squash eaten together cause leprosy (Valdecañas 1972). Another study shows the direct relationship between the education of mothers or heads of families and the nutritional status of families, i.e., as the number of years of schooling increased, the average diet rating improved (Philippines, FNRI 1958-69).

Crowded living space, lack of basic community services, and poor environmental sanitation still afflict most of the population in developing countries and adversely influence their nutritional status. The 1973 National Survey found that only 32% of households in the Philippines had sanitary toilets, and only 16 million people had potable water. In response, social services in the fields of housing, health, education, and social welfare are being intensified and settlement projects are being instituted to relieve the congestion in depressed urban areas.

To summarize, nutrition goals in social development planning will be:

1. To promote sound dietary habits through an intensive information, education, and communication campaign utilizing community workers, the mass media, and formal and informal education facilities;

2. To establish more day-care centers for preschool children, and encourage school food programs.

THE PHILIPPINE EXPERIMENT IN NUTRITION PLANNING

Because of the multidimensional character of the problem of malnutrition, the Philippine Nutrition Program (PNP), is organized as a collective effort of various agencies and organizations. Although essentially a program for coordination, the PNP has two broad functions: coordination and implementation. In its coordinative function, the PNP seeks to integrate the projects of the various agencies into a single program. The implementation function is performed by the agencies whose organizational mechanisms run parallel to those of the PNP.

On the whole, the PNP is best defined as the sum total of individual and collective efforts planned and organized to solve the problem of malnutrition in the Philippines. It now forms an integral part of the Government's development program.

In June 1974, Presidential Decree 491 created the National Nutrition Council (NNC), and vested it with the responsibility of formulating a national program for nutrition and coordinating all nutrition-related activities of the various agencies of the government and of the private sector, The Council is composed of heads of the different agencies engaged in nutrition work: The Secretaries of the Departments of Agriculture (Chairman), Health (Vice-chairman), Education, Social Welfare, Local Government and Community Development; and the Chairman of the National Science Development Board. The private sector is represented by the heads of the Nutrition Center of the Philippines, the Nutrition Foundation of the Philippines, and the Philippine Medical Association.

At the national level, the NNC is the nerve center for planning and coordination. The Executive Director implements the policies, programs, projects, and decisions of the Council. He heads a Secretariat that facilitates and monitors NNC activities and operations. The Management Committee, assisted by the Secretariat, is composed of representatives of member agencies of the Council.

The first objective of the PNP is the establishment of an active organizational structure at all levels of operation. At the local levels below the NNC are regional, provincial, municipal, and barangay (village) nutrition committees composed of government and civic leaders. The committees are headed by the highest political leader at the given level: the Governor in the province, the Mayor in the municipality, and the barangay Chairman in the village. The responsibility for successful implementation of the nutrition program, therefore, rests on local government leaders. They are no longer honorary chairmen as in the past; they are to account for the success or failure of nutrition programs in their areas.

Implementation of the program at the grass roots level is through the Barangay Network, which serves as the final link between the nutrition agencies and committees and the target families. The network is composed of a team of teacher-coordinator and purok-zone leader and a number of unit leaders, each taking charge of about 20 family clusters in the community. The network is to serve as a two-way system for delivery of nutrition services and information as well as to conduct health surveillance of the population.

The state of nutrition of the population may be gleaned from the nutritional status of the preschool children who are among the priority targets of the nutrition program. Therefore, the initial activity of the PNP is a nationwide weight survey that will form the basis for planning local nutrition programs. Operation Timbang (OPT) identifies malnourished children below 6 years in each household in the community. The cases are categorized as mild, moderate, or severe undernutrition, according to their weight for age and height so that priorities can be determined for program implementation, and appropriate corrective as well as preventive measures can be instituted. OPT also monitors the efficiency of local nutrition programs.

The PNP has devised five intervention schemes whose implementation requires the cooperation of and coordination among the various government agencies. They are food assistance, food production, health protection, nutrition education, and family planning.

Food assistance, in the form of food supplements to the severely malnourished children identified by OPT, is resorted to only in extreme emergency cases.

Food production encourages home gardening and school or community gardens, and the raising of livestock and poultry. Emphasis is on planting locally suitable foods that are rich in nutrients usually lacking in the average Filipino diet, especially crops that are easy to grow: root crops, legumes, and green leafy and yellow vegetables.

The health protection program provides emergency medical treatment by a physician, a rural health unit, a hospital *malward* (malnutrition ward), or any qualified personnel, for care of malnourished children. It also undertakes preventive measures in the form of immunizations–particularly of children – to control the incidence or spread of disease, and dietary and medical advice to mothers of malnourished children, as well as to pregnant and nursing women.

In nutrition education the targets are the parents, especially the mothers, because they can best influence the food habits of the most vulnerable groups – their preschool and school children. The information and education campaign is carried out on several fronts: interpersonal media through the nutrition field-workers of the different agencies, nutrition education in the elementary and secondary schools, and the mass media.

Finally, information on family planning is included in homemakers' classes held at the grass roots level. In the barangay, nutrition field-workers assist in identifying, through the barangay monitoring system, the families who desire help in family planning.

Using data obtained from OPT as basis for action, the PNP has identified the municipality as the focal point for planning and implementation. The municipal planning process starts with those closest to the problem. The first step is to discover the extent of the malnutrition problem in a given locality, including the identification of critical areas needing priority attention. The objectives are then defined, intervention schemes are selected, personnel and logistics required are decided upon, time schedules are set, and agencies to be involved are identified and their roles defined. The plan is then submitted to the city or municipal council for funding assistance, as some aspects of the plan may require support from the municipality. Finally, the plan is submitted to the NNC for coordination and support.

PROBLEMS IN NUTRITION PLANNING

To overcome a problem as massive as malnutrition, government intervention is necessary. As a focus of government attention, however, nutrition assumes a highly political character: political power is basic to making and implementing decisions. From the politicians' viewpoint the nutrition cause is hardly glamorous. The complexity of the problem, and the fact that the targets or beneficiaries of action (the malnourished poor) do not by themselves have great political weight, are not likely to make nutrition capture the political imagination. Thus, in many developing countries, support from the top may neither come automatically nor attain a significant level.

Assuming that governments address themselves seriously to the problem, implementation is often difficult. The administrative machinery and its administrators' competence may be inadequate for sustained activity in the countryside, and the multisectoral nature of the problem exposes it to conflicts of bureaucratic interest. In any collective effort, roles and functions may be expected to overlap or compete with one another at certain operational points or organizational levels. Reconciliation of differences, particularly among autonomous organizations, is not generally an easy task.

CONCLUSIONS AND RECOMMENDATIONS

For effective sectoral and national planning in nutrition, the following points must be stressed:

1. Strong decision and commitment from the highest levels of government are needed to give impetus to a national nutrition effort.
2. The coordinated nature of nutrition planning needs a strong institutional base for implementation. To be effective, such an institutional base must be autonomous.
3. The goals and requirements of nutrition demand effective articulation at the highest planning levels of government. Nutrition-specific planners should be appointed in the central planning office to see to it that the nutrition program is strategically incorporated into the national development plan.

4. Some form of politicalization is necessary to pressure operational institutions to act effectively for nutrition objectives. The source of this political power can be the general public, or the expression of the public's urgent needs.

5. Ideally, planning should start from below. The goals set should be realistic, i.e., closely based on operational resources and requirements. Realistic planning is best achieved by enlisting the participation of the people in target communities from the very start of the planning process.

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Discussion

In the Philippines Nutripak scheme, the use of local ingredients is emphasized: rice is the base, to which powder of shrimp or other fish and fresh vegetables is added. Allergic-type reactions are sometimes observed, probably because histamine is released from shrimp or fish. Nutripak now sells for the equivalent of US7 cents. The goal is to make it available in the village stores. Nutripak supplies 50% of the recommended dietary allowance (RDA) of calories and protein. The present average diet of low-income families supplies only two-thirds of the RDA for protein and energy for the age group 6 months to 6 years.

There should be a cutoff age for the use of the weight or height for age criteria to detect protein-energy malnutrition, because markedly underweight and short children of 4 to 6 years may in fact be displaying the effects of malnutrition suffered at a still earlier age. Weight: height ratios must be used for older age groups, and dependence on weight and height for age measurements should be limited to children under 3 or 4 years.

The Operation Timbang approach is family-centered, and families with a child with third-degree protein-energy malnutrition (60% of the standard weight for age) receive intensive nutrition services that include education, birth-control pills, vitamin A capsules, and food subsidies. Statistical analysis of the data has shown that the third-degree malnutrition figures were correct; the second-degree (60 to 75% of standard weight for age) figures were overestimated by 20%; and the first-degree (75 to 90%) figures were overestimated by 50%. Concentration on the third- and second-degree cases as the first target groups sidestepped the overestimation.

Nutrition goals for sector planning and national planning: workshop summary

The problems of nutrition are so complex that nutrition planning has to be multisectoral. However, the lack of sector interest in nutrition prevents decision makers and national planners from realizing its importance.

A major problem that has delayed political action in some countries is lack of proper communication. Decision makers and national planners need to see clear-cut, cost-benefit effects before they assign priority to nutrition in national development. The cost benefits that accrue from improved nutrition in terms of lives saved, increased productivity of workers, and lower health-care costs must be emphasized. The well-known effects of good nutrition on the physical and mental development of children are good arguments for convincing politicians, but the information presented to them must be simple, clear, brief, and based on accurate statistics. Reduced child morbidity and mortality, and the relation of child survival to family planning should also be stressed.

An effective administrative system is essential if food and nutrition considerations are to be incorporated into national development planning. There is need for a high level body or forum, transcending interdepartmental boundaries, to provide the leadership in nutrition planning. This body need not be a new separate body or department. In countries where creation of formal commissions is not possible, attaching an ad hoc nutrition committee to the national planning body is recommended. Each agency should identify its specific commitment and coordinate its involvement with the national development plan at all levels of government, from top to bottom.

Such a body must havedefinite plans to bring nutrition planning to the grass roots level, and must involve the local administrative bodies. A simple, community-oriented food technology industry should be set up in rural areas to produce low-cost, nutritious foods for the poor. Such intervention will readily make apparent the interface between agriculture, food science, and nutrition.

The working group considered the proper use of the press and other mass media to be a great help to a nutrition intervention program.

Finally, discussion emphasized the lack of trained manpower and nutrition-oriented planners in many developing countries. There is an urgent need for people trained in various disciplines to focus on nutrition planning and implementation in national development plans. It was recommended that the United Nations University expend more effort in this area, both through its associated institutions and through meetings and workshops such as this one.

The following recommendations from Dr. Solon's paper were strongly reemphasized:

1. There is need for firm decision and strong commitment at the highest levels of government to mount a national nutrition effort.

2. The coordinated nature of nutrition planning requires a strong institutional base for implementation. To be effective such an institutional base must be autonomous.

3. The goals and requirements of nutrition planning demand effective articulation at the highest levels of government. Nutrition-oriented planners should be appointed in the central planning office to ensure that the nutrition program is strategically incorporated into national development plans.

4. Political pressure, exerted by the general population, will be necessary to force operational institutions to adopt nutrition objectives. The mass media can help create a political awareness by publicizing the public's urgent nutritional needs.

5. Nutrition planning ideally starts at the community level, and the goals set should be closely based on actual resources and specific requirements. Realistic planning is best achieved if people in the target communities participate from the very start of the planning process.

PROBLEMS

To help the agricultural sector contribute toward the solution of the problems of nutrition in Southeast Asia, food deficiencies must be identified in terms of both quantity and quality. The major and most urgent problems identified follow:

1. To supply adequate calories for most people in developing countries, more food is required, particularly staples (rice, maize, wheat, etc.) and fat. Food must be produced in quantities sufficient to meet nutritional needs beyond the per capita recommended dietary allowances (RDA) because the per capita criterion conceals maldistribution within the community. Allowance must also be made for the inevitable postharvest losses before agricultural production and national consumption can be correlated.

2. Production and consumption of protein-rich foods of both plant and animal origin must be increased to meet the needs of vulnerable groups, e.g., pregnant and nursing women, and infants. Especially needed are legumes and oilseeds. Backyard production of legumes and the rearing of small animals such as poultry should beencouraged. Poultry and swine can be fed household table scraps and other feeds that cannot be used as human food. Use of grain for animal fodder should be reduced.

3. Production of fruits and vegetables should be further encouraged, as they are excellent sources of vitamins and minerals. Household production can be either for home consumption or for sale as cash crops. The purchasing power of rural farming communities can be stimulated by additional diverse crops.

4. Research on how to decrease production costs to raise the farmer's income and increase yields to reduce food prices is needed.

5. Cassava and other root crops such as sago and sweet potato should not be direct substitutes for Irish potato, rice, corn, or wheat. They are, however, a valuable energy source when the diet is supplemented with more concentrated sources of protein such as legumes, oilseeds, and fish.

Some difficulties are associated with the major problems:

1. In the past attention was concentrated on rice production; only in recent years have efforts been directed toward other foods.

2. There is no available technology that can be incorporated into the cropping system now existing in the countries of the region.

3. Agricultural technology has benefited large growers, but has not been of value to small farmers.

4. Agriculture has been export-oriented; food for domestic consumption must now receive greater emphasis.

5. Too many farmers are landless.

6. Marketing and distribution of food are inefficient.

7. Huge postharvest losses of food occur because of insects, mold, and simple spoilage.

8. There has been little specific encouragement to produce nutritious foods.

9. Both producers and consumers lack knowledge of what constitutes good nutrition.

RECOMMENDATIONS

1. Government incentives and efforts should be directed toward improving the economics of producing nutritious foods, including improved yields of legumes and other body-building foods. However, these efforts must be combined with measures to increase the food-purchasing power of the poor. A better-fed population will eventually increase effective demand and improve purchasing power. At present, producers are basically supplying effective demand that is usually less than the consumers' nutritional needs.

2. Animal husbandry should be promoted to help meet requirements for animal protein within the framework of developing countries' economies. Ruminants should be grass-fed or should consume vegetable wastes to the maximum extent possible. Similarly, the use as nonruminant feed of food edible for humans should be minimized. The practice

of using grain largely for animal feed, characteristic of many industrialized countries, should be avoided in developing countries. Food balance sheets should explicitly categorize where potential human food may be used for animals.

3. In line with increasing the importance of nutrition in national development, national and international agricultural research centers should give greater priority to commodities that may have lower cash value but are important in improving the diet of lower-income populations.

4. Nutritionists should recommend ways in which food scientists can help agriculturists achieve these nutrition goals. Food preservation and packaging methods should be improved–with emphasis on food processing at the village level–to make use of simple, locally available technology. Simple, acceptable, convenient, and nutritious processed foods should be developed at the lowest possible cost. Examples are vegetable-protein mixtures and dried fish-cereal mixtures for use as weaning foods.

5. Expensive and imported foods should be replaced with local or cheaper indigenous food crops. Examples include soy products and legumes in place of meat, and flour made from roots and tubers or coconut meal to replace imported wheat in bread.

6. Nutrition education should be given emphasis at all levels of society to inculcate good eating habits in all age groups.

ONE FINAL COMMENT

Closer cooperation among agencies involved in agriculture, nutrition, and food science is needed and should be further promoted nationally, regionally, and internationally by the International Union of Nutrition Sciences and its members.