INCAP Publication I-1530

Completing the Food Chain

Strategies for Combating Hunger and Malnutrition

Papers and Proceedings of a Colloquium Organized by the Smithsonian Institution

Smithsonian Institution Press
Washington and London

Edited by Paula M. Hirschoff

and Neil G. Kotler

CHAPTER 10

Food Science, Technology, and Agroindustry

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Science and technology have contributed significantly to improving food systems. This paper discusses the potential of food science and technology in two specific areas: the development of standards to measure food crop quality and the use of agroindustries to improve the food system.

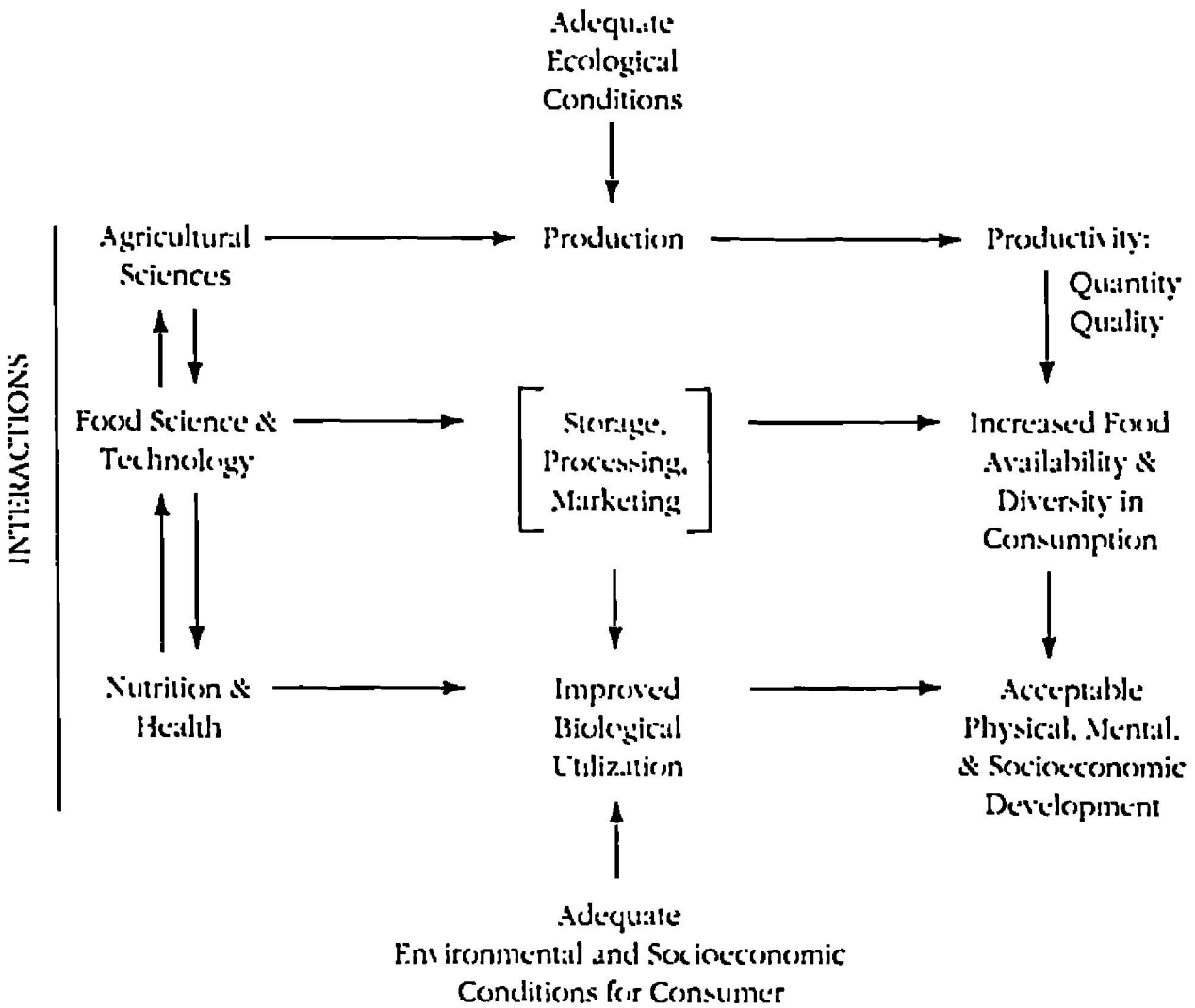
To be successful, both tasks require the active participation and exchange of ideas and experiences of professionals from a number of disciplines. In addition, both tasks require active participation by consumer groups, who must decide what improvements they would like and how they can help achieve them. In addition, market forces must be carefully considered throughout the process. In fact, balancing market and consumer concerns is the most difficult problem facing a developing country in its efforts to improve food systems.

The Food Chain

At the most basic level, achieving food and nutrition security means increasing food production. A more complex explanation takes into consideration a number of components, including the food chain.[1] The interrelationships of various disciplines and their activities and outputs are shown in figure 10–1. The environment's capacity to produce is linked with the environment of the consumer population, which should be able to utilize the outputs of the entire system.[2]

Figure 10–1.

The Food Chain: A Multidisciplinary System to Deliver Food and Nutrition to Consumers



Food Crop Quality Objectives

Until very recently, the main objective of agricultural scientists was to increase productivity, or production per unit of land, by applying scientific and technological research findings. Although no one can deny the significance of this objective, these efforts failed to take into consideration the needs of the target population, such as decent conditions for production, food acceptability, and nutritive value.[3] These are the elements that determine food crop quality. Food science and technology can contribute significantly to food quality by identifying, defining, and developing methods to evaluate food storage, processing, acceptability, and bioutilization.

Grain quality characteristics for common beans, for example, are shown at different points on the food chain in figure 10–2.[4] At the production stage, farmers expect high and stable yields, which are obtained through proper breeding and disease-resistance measures and acceptable cultivation practices. At harvest time, farmers want pods of uniform size and color that reach physiological maturity at the same time, and grain that separates easily from the pod. At the storage stage, farmers want insect-resistant beans that retain their color and that develop slowly to the hard-to-cook condition—namely, qualities that the consumer finds acceptable.

The user, whether a housewife or a food industry, wants to process a bean with a thin seed coat, stable color, rapid hydration, short cooking time, and a thick-cooking liquor. Processing should be effective enough to eliminate antinutritional factors without affecting the bioavailability of other nutrients. The bean nutrients, particularly protein, should also be highly available and effectively supplement other staple foods.

The task is to identify and define these attributes and to develop appropriate methodology for selecting and evaluating their presence in

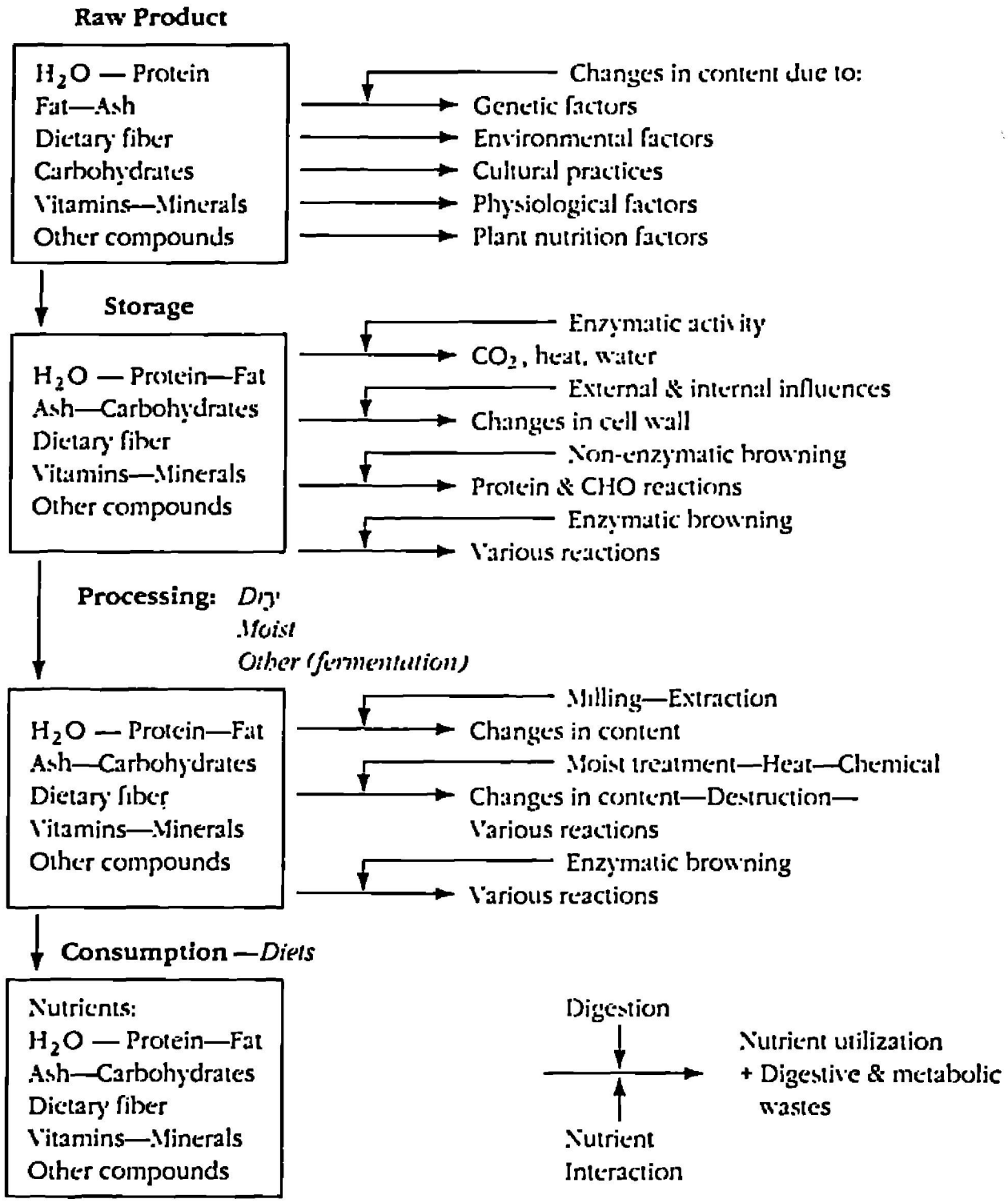
Figure 10–2.

Grain Quality Attributes for Common Beans

Area	Attribute
Production	High and stable yields Homogeneous pod dry down
Harvest	Good separation and recovery of grain from pod Uniform seed size and color
Storage	Resistant to insects and to development of hard-to-cook condition Color stability
Processing (home and industrial)	Rapid hydration Short cooking times Thick-cooking liquor Color stability Low seed-coat content
Biological Utilization	Good acceptability (site specific) Free from antinutritional factors High digestibility and protein quality

Figure 10–3.

Chemical Compounds and the Food Chain



the grains. This requires a multidisciplinary approach involving agricultural scientists, food scientists and technologists, and nutritionists.

This approach is so vital to achieving high quality in food grains that it is necessary to expand on it, even though it may seem obvious.[5] Figure 10–3 shows the different steps in the food chain and lists the major chemical compounds present in food. These compounds are responsible for the characteristics shown in figure 10–2. The compounds are affected by many factors, such as genetic makeup, environmental conditions, cultivation practices, and disease and nutrition of the plant or animal. The seed is biologically active during storage, which influences the stability and content of the chemical compounds. External factors also influence the biological activity of the grain, but those changes may be subtle and difficult to evaluate. The same chemical compounds are susceptible to change during processing, but these changes can be controlled. Finally, the chemical compounds become nutrients when the individual consumes the food.

Utilization of the nutrients in the food depends on both the individual effects of external factors particular to each link of the food chain and on the interaction of the nutrients in the foods making up the diet. The chemical compounds offer the means to evaluate and quantify grain quality factors.

Thus, to attain high-quality food crops, the concerted effort of many disciplines is required. The food scientist develops the methodology to evaluate the crops, although the ultimate evaluation comes in the marketplace.

Food Science, Technology, and the Role of Agroindustry

Another important role of food science and technology is to improve food systems in the areas of production, marketing, and bioutilization. These include increased opportunities for crop utilization as food; increased efficiency in weak links of the food system, such as better storage to retain grain integrity and to reduce food losses; processing of feed and nonfood products for other production-processing systems; and the incorporation of food processing at home or in industry for better use of food crops and/or preservation for future consumption.

Agroindustries are often mistakenly perceived as processing units, rather than as important components in a food system. However, when they are integrated into food systems, they can complement both production and marketing activities. Conceived in such a way, agroindus-

tries not only contribute to economic development, but also help solve the population's nutritional problems.[6]

Agroindustry's role is also commonly misconstrued as limited to processing and converting crops to food products for human consumption. Too little attention is directed to processing activities designed to utilize residues and by-products in nonfood products, thus enhancing the value of the entire system.

Agroindustries can significantly improve the food system in a number of ways. Figure 10–4 shows areas in the food chain where agroindustries could be involved.[7] They may, for example, be useful in selecting and storing seed for improved production or improved marketing schemes.

Common agroindustry practices are to market select agricultural products in different sizes, shapes, and colors; to charge more for a product when it is fresh; and to label processed products as second or third class. The development of storage facilities so the product can be marketed off season is another approach. Processing can serve to reduce losses at times of high production. It is also important to remember that the processed foods should be included in the diet of the rural population as well as marketed elsewhere.

The market and agroindustry considerations are fundamental to food system improvement. Both can play an important role in promoting the quality and quantity of agricultural production based on market demands. Breeders, agronomists, food technologists, and food scientists, as well as marketing specialists, can work together with organized production and processing groups (cooperatives, for example).

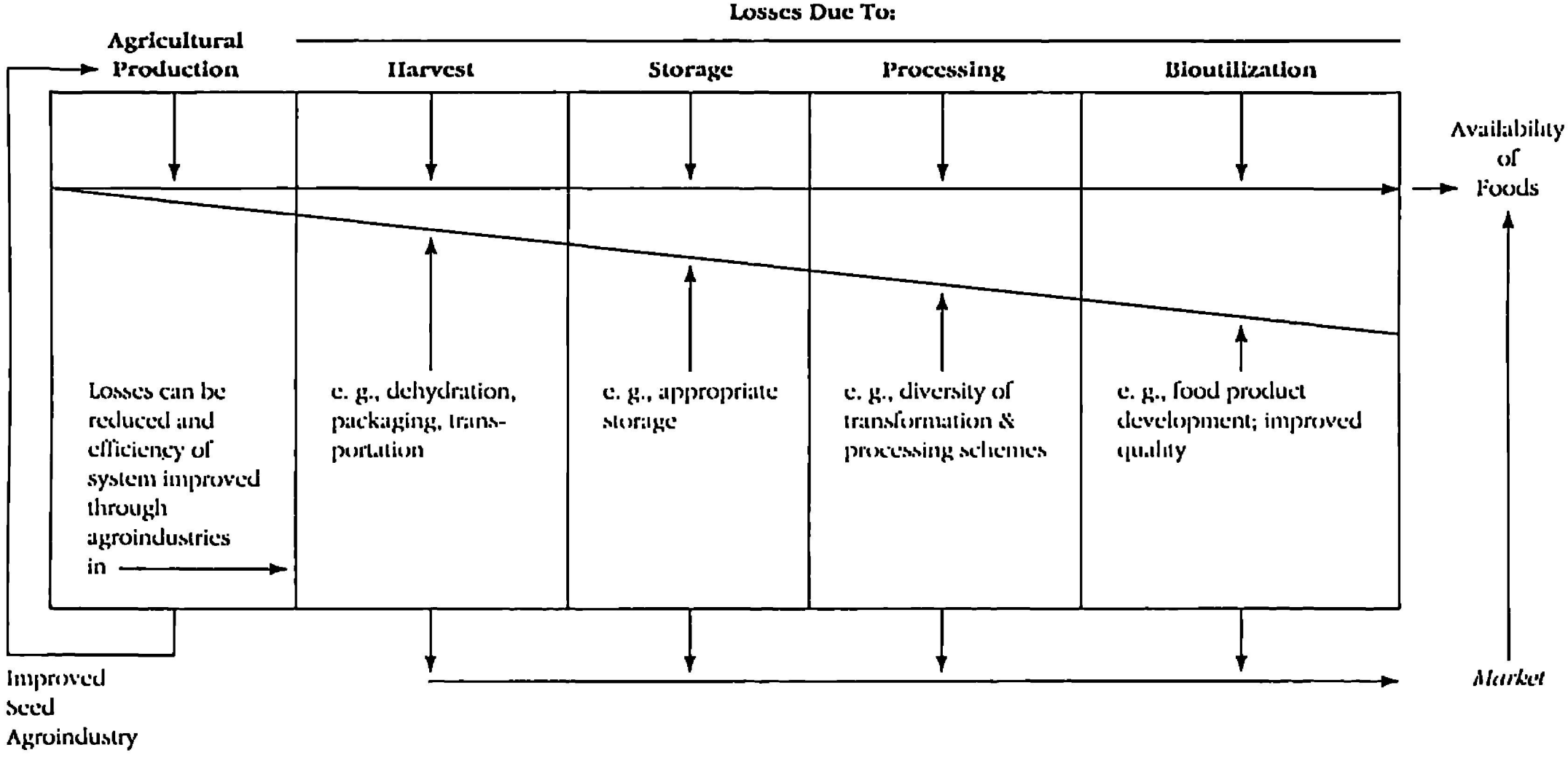
It is common for fruits, vegetables, and other perishable crops to be transported to market by truck. The produce is piled relatively high and the weight of the products, the bouncing of the truck, and the exposure to sun and rain cause much damage. Thus, important improvements could be made in packaging for transport.

It is also common to see immature maize piled in the market to be consumed as ear corn. Farmers can easily obtain three to four times more for corn sold in this manner than for corn sold dried or mature. The losses are very high due to the lack of cool storage or any storage facilities at all. Processing of this immature corn would be a profitable activity, particularly if the green plants left in the field were used to feed animals and the fresh green husks and ears entered other production systems.

Studies should be conducted on how the local people use particular crops. For example, sorghum is considered a second-class grain, but many products are made from its flour or grain in the regions that produce it. A popular example is popped sorghum grain. (Popped corn using imported grain also has become a popular snack food.)

Agroindustries that process agricultural residues can significantly

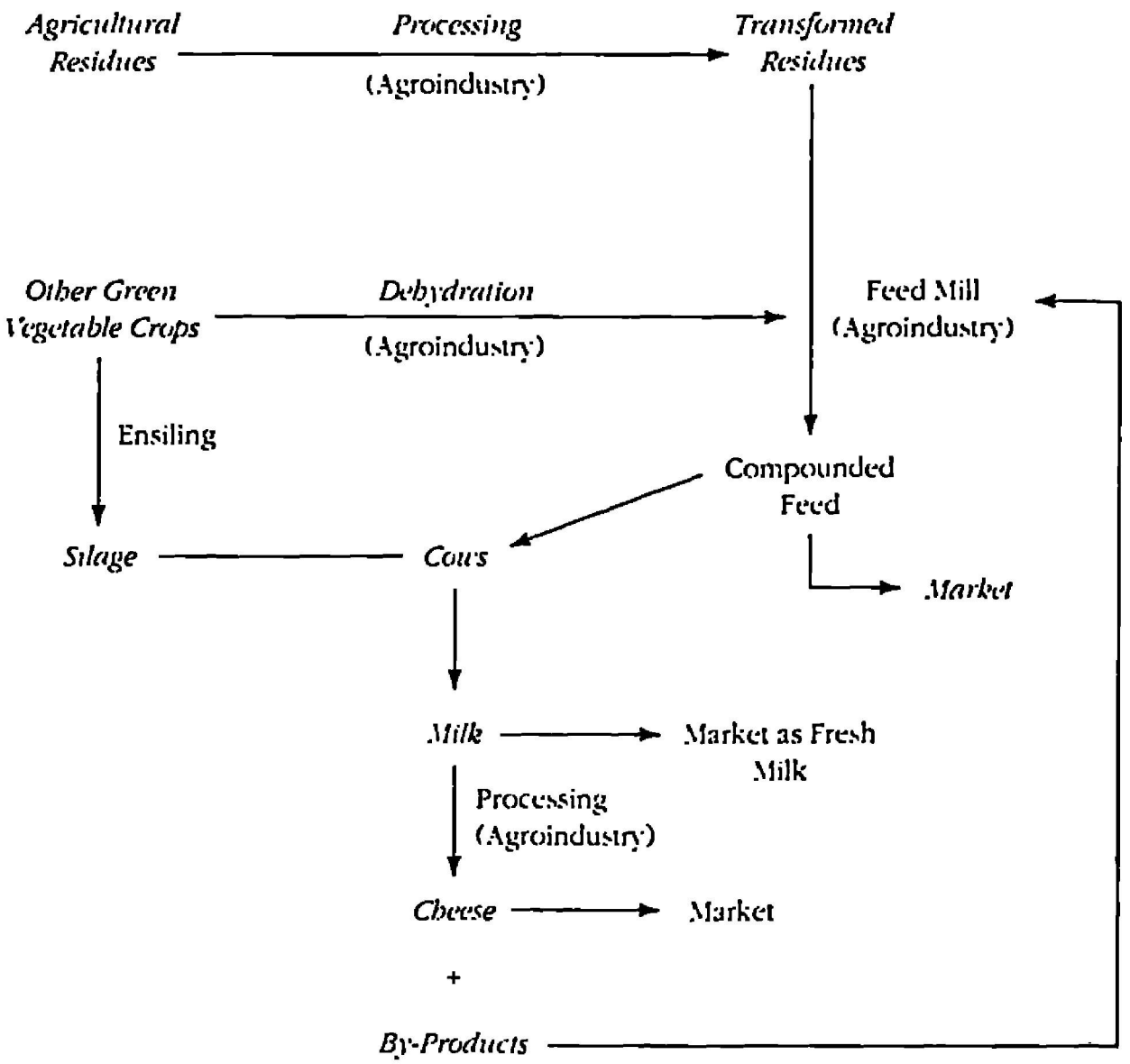
Agroindustries in the Food Chain



Source: RETADAR (1985): 16.

Figure 10–5.

Increasing Milk Production in the Guatemala Highlands



improve food systems. In some areas, the land available for food crops is limited because it has been subdivided so many times and because the production of cash crops has taken precedence. Owners of land dedicated to food crops often wish to have available animal food products such as meat and milk, but they lack grazing land. They can still produce animal food products, however, by converting agricultural residues into acceptable feeds through a number of technologies such as ensiling. For example, four different agroindustries can play a role in producing milk in an economically attractive way. This would involve the processing of agricultural residues; the dehydration of vegetable crops; the conversion of residues into feed; and the processing of milk into milk products such as cheese (see figure 10–5).

Food and nutrition programs can be undertaken in different regions of a country by using the specific crops of a region to prepare flours with a high energy and protein content. These can be made more acceptable in quality through the joint efforts of producers, processors, and consumers by producing better quality raw materials, using adequate processing, and selecting for food characteristics that combine consumer preference and nutrient value.

Although the above examples apply to rural populations, urban groups involved in food processing and distribution can also benefit from food system improvements. A recent study on food vending in Guatemala City cited many appealing processed foods. The quality of these foods can be upgraded by improvements in the raw materials, processing techniques, packaging, and by distribution to a wider market.

Agroindustry has tremendous potential to improve food and nutrition through advances in food systems. It is important, however, to develop a methodology to select the more successful techniques and to collaborate with various disciplines in the effort to improve the well-being of malnourished people in developing countries.

Market Development

There is no doubt that agroindustrial development is an important activity that is very often ignored in food system development. The fact that most of the world's successful agricultural economies also happen to be industrialized is not purely accidental. Expanding the technological capacity of farmers is vitally important to agricultural production, and diversification of production appears to strengthen technological capacity. It is important to remember, however, that agroindustrial development tends to be a long-term process, one that yields results only after years of careful planning.

An important step to accelerate agroindustrial development is identifying and developing markets, as well as increasing the purchasing power of the consumer. Important market considerations include the advantages of an assured market, such as school feeding programs, and export demands where high quality is a fundamental factor. The product, whatever it is, must have a clear identity derived from the need that it fulfills in the marketplace.

Agroindustries must then be created and developed on the basis of need. One obvious need is to strengthen national economies through agroindustries that increase exports or decrease imports. There is also a need to ensure the availability of seasonal foods (such as fruits), to reduce harvest losses, or to use products such as fresh foods that do not meet all

quality standards. A further need is to develop products to be used in specific food and nutrition programs, such as highly nutritional foods for infants, preschool children, and pregnant and lactating mothers. Government-sponsored school feeding programs may market such foods.

Also important is the conversion of agricultural residues for use in other food production systems. For rural societies that depend on farming for their livelihood, this type of agroindustry is essential. Agroindustries should be able to produce and make available intermediary products, or food product ingredients such as human-grade cottonseed flour. Ingredients can be produced to enhance color, flavor, and texture; to fill gaps in the food chain; to preserve the environment; and to produce useful products. Agroindustries should preserve and improve native technologies, particularly for products that are popular in the local diet.

A final and important point is the need to analyze the reasons for the low incidence or complete absence of agroindustries in developing countries. Understanding this phenomenon should facilitate the development of food and feed agroindustries. One possibility is that at one time foods were readily available in these countries most of the year, thereby making unnecessary the processing of foods by agroindustries. Additional possible explanations include the lack of household equipment for food storage and processing, the absence of consumer markets as a result of poverty and diminished purchasing power, and, in addition, insufficient supplies of food beyond that used on a daily subsistence basis.

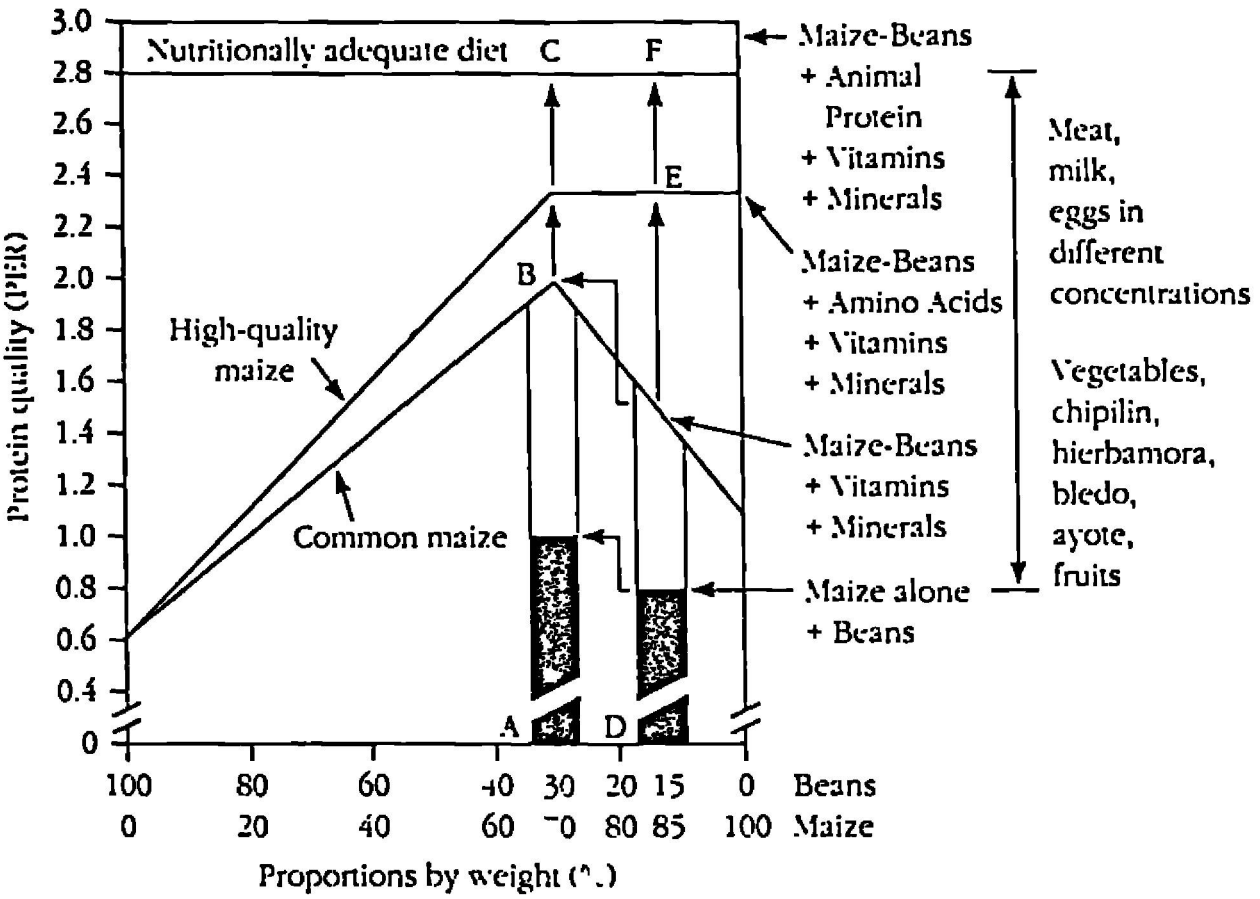
Integrating Production and Consumption Systems with Food Processing

Food science and technology can play a key role in improving nutrition by linking food production, food processing, and food consumption.[8] The food production system of farmers with small or medium capacity to invest has the objective of maximizing land use by growing a variety of compatible crops and ensuring food security and income. Production will vary, depending upon the particular food crops, or combination of crops and livestock production. The underlying goal of food consumption systems, of course, should be improved nutrition—not only by maximizing nutrient bioutilization, but also by educating the consumer about nutrient deficiencies in foods and how to correct them by consuming other foods.

In the example given in figure 10–6, protein quality responses to a number of common maize-bean mixes are shown. Two combinations of maize and beans representing the present intake (D) and the optimum

Figure 10–6.

Nutritional Improvement of the Maize-Bean Consumption System

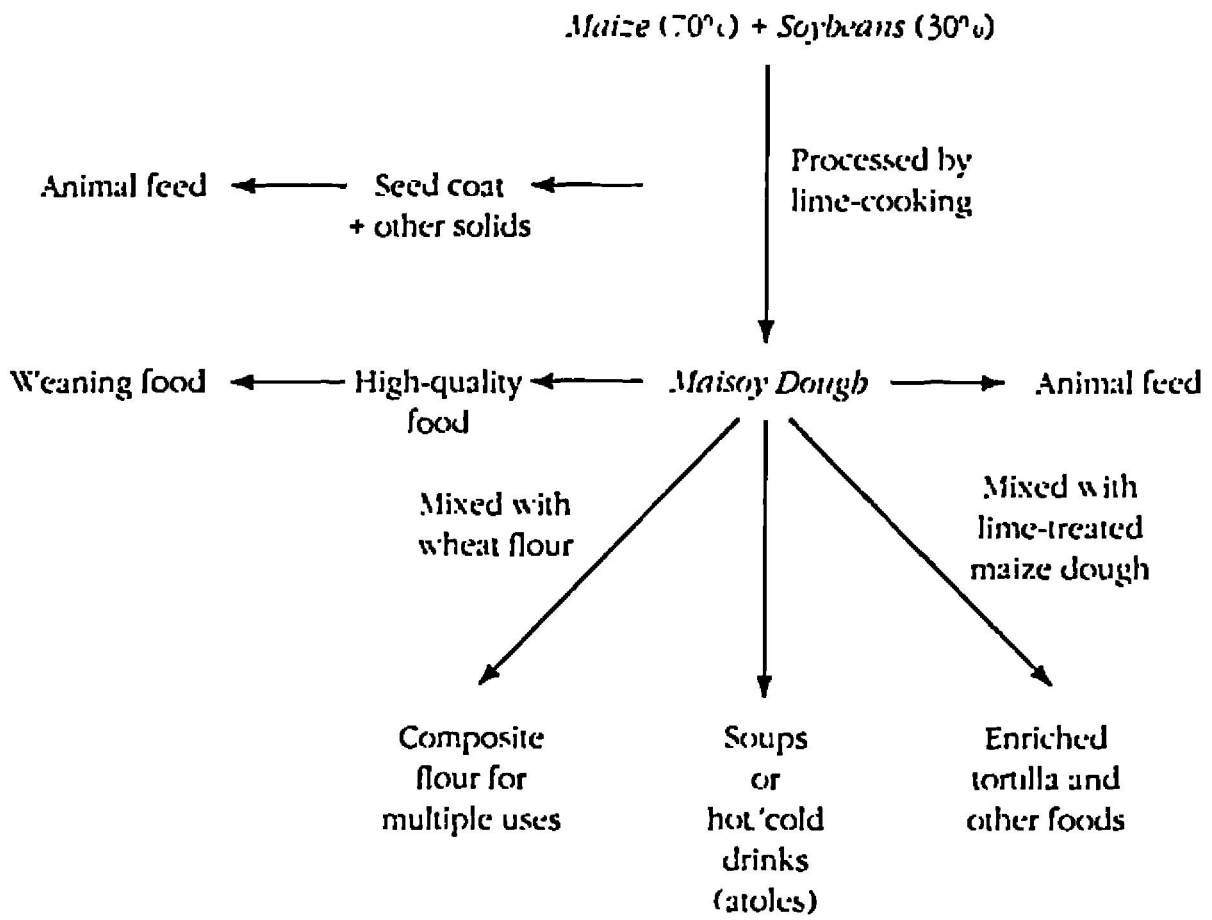


intake (A) have been supplemented with different foods shown at the far right of the figure. These provide the nutrients that would improve the quality of the basic maize-bean mixture. Changing the ratio of maize and bean intake from D to A and adding food sources of vitamins and minerals, such as green vegetables, increases the quality to point B. Point E can be reached by replacing common maize with high-quality protein maize,[9] while points C and F can be reached by consuming small amounts of animal food. Achieving better nutrition and food consumption through the production of animal products as components of farm systems has proved to be technically and economically feasible, at least under experimental conditions.[10]

Agricultural production and food consumption can be further improved by the use of a variety of food processing techniques. An example is shown in figure 10–7. Nutritional studies have shown that a food high in protein and relatively high in fat is obtained when maize and soybeans are mixed in a seven-to-three weight ratio through industrial processing. However, the same food can be obtained through proper training within

Figure 10–7.

A Food Processing System Based on Maize and Soybeans



the household, provided soybeans become available and people learn to process them. For example, lime cooking, one of several technologies tested, can be applied to the raw grains and results in a dough with multiple applications ranging from foods used for weaning infants to animal feeds. It can also be mixed with wheat flour, maize, and other grains to produce foods such as cookies, soft-dough breads, and tortillas, which will introduce variety in the meal and improve nutrition.[11]

Furthermore, maize and beans and other crops grown on small areas of land can be used to produce animal feed products. The theoretical example in table 10–1 demonstrates that with integrated approaches, it is possible to achieve diets that respect dietary habits, offer a variety of foods, and provide good nutrition.[12] The crops used in this example are grown on many small farms; if environmental conditions do not permit their production, alternatives can be found. Such systems have not been tested in an integrated form, although it would be worth the effort to test them in practical situations. Education must also be carried out along with agricultural activity and processing. Finally, an economic evaluation of these systems presents opportunities for multidisciplinary solutions to the problems of food deficits and nutritional deficiencies.

Table 10–1.

The Integration of Food Production and Consumption to Provide Highly Nutritious Diets

Food Consumption	Foods (grams/person/day)					
	Maize	Beans	Plantain	Soybean	Meat	Protein-Rich Vegetables
Maize-beans	59.5	19.5	—	10.5	—	—
Maize-soybean (gruel)[2]	35.0	—	—	15.0	—	—
Beans-plantain	—	20.0	80.0	—	—	—
Maize-soybean (tortilla)	85.0	—	—	15.0	—	—
Meat-maize-beans[1]	72.0	8.0	—	—	20.0	—
Vegetable-maize-beans[1]	85.5	9.5	—	—	—	5.0
Total/person/day	422[2]	57	80	55	20	5
Total/family/year (kg)	411	55	78	54	20	5
Hectares of land	0.34	0.11	—	0.03	14 p	—

Protein content total: 81g; 12.7%

Utilizable protein content (%): 65g; 10.2% (80% BV)

Calorie content total: 2292 cals;[3] cals/100g: 360

Digestible calories content: 2177 cals; cals/100g: 342 (95% utiliz.)

Relationship protein calories/total calories: 12[4]

Notes

1. Can be rice-beans.
2. Average 18 tortillas/day (adult).
3. The calories increased with the consumption of other foods not considered within the food consumption systems, such as sugar, fat, vegetables, and fruits.
4. Reduced to 9 when caloric content increased.

Notes

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3. Ibid; R. Bressani, "Una Vista Integral del Problema Agroindustrial Alimentario Latinoamericano, Algunas Consideraciones sobre el Desarrollo Agroindustrial Latinoamericano" (Paper presented at seminar "Desarrollo Agroindustrial Rural en América Latina," RETADAR, San José, Costa Rica, April 15–20, 1985).

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7. R. Bressani, "Una Vista Integral."

8. R. Bressani, "Situación Actual." R. Bressani, "Sistemas de Producción, Alimentación, y Nutrición" (Paper presented at seminar "Taller Regional sobre Elaboración de Hojas de Balance de Alimentos," CADESCA, Guatemala, July 27–31, 1987).

9. National Research Council, *Quality Protein Maize* (Washington, D.C.: National Academy Press, 1988).

10. R. Bressani, E. Ibáñez, and J. M. González, "Small-Scale Integrated Agricultural Production," *Family Farm, Food, and Nutrition Bulletin* 8 (1986):30–36.

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12. R. Bressani, "Situación Actual."