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UNIDO MONOGRAPHS ON INDUSTRIAL DEVELOPMENT

Industrialization of Developing Countries: Problems and Prospects

FOOD-PROCESSING INDUSTRY

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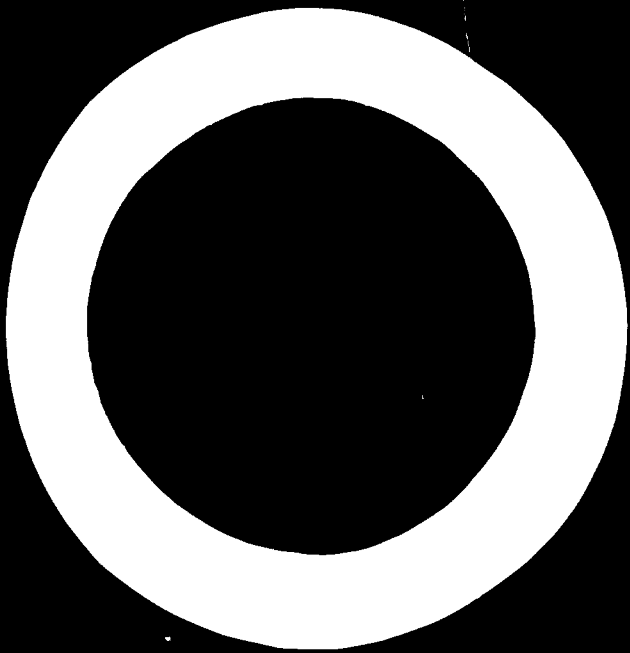
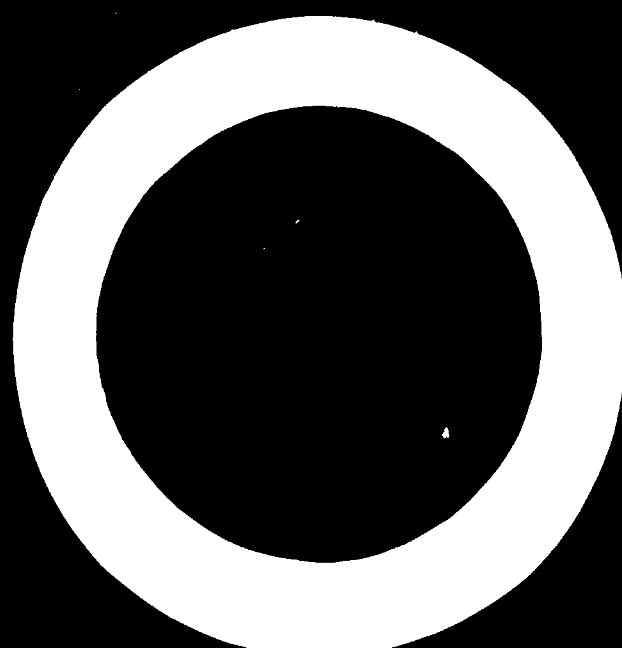
UNITED NATIONS





FOOD-PROCESSING INDUSTRY

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
VIENNA

UNIDO MONOGRAPHS ON INDUSTRIAL DEVELOPMENT

*Industrialization of Developing Countries:
Problems and Prospects*

MONOGRAPH NO. 9

FOOD-PROCESSING INDUSTRY

Based on the Proceedings of the International
Symposium on Industrial Development
(Athens, November-December 1967)

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Foreword

The International Symposium on Industrial Development, convened by UNIDO in Athens in 1967, was the first major international meeting devoted exclusively to the problems of industrialization of the developing countries. It followed a series of regional symposia on problems of industrialization held in Cairo, Manila and Santiago in 1965–1966 under the sponsorship of UNIDO and the United Nations regional economic commissions, and a similar symposium held in Kuwait in 1966 under the sponsorship of UNIDO and the Government of Kuwait.

The Athens Symposium was attended by some 600 delegates from 78 countries and by representatives of various United Nations bodies, international organizations and other interested institutions in the public and private sectors. It provided a forum for discussion and exchange of views on the problems and prospects of the developing countries which are engaged in promoting accelerated industrial development.

The Symposium devoted special attention to possibilities for international action and for co-operative efforts among the developing countries themselves, and explored the scope, means and channels for such efforts.

Studies and papers on a wide range of problems relating to industrialization were presented to the Symposium—by the UNIDO secretariat and by participating Governments, international organizations and observers. An official report, adopted at the Symposium, has been published by UNIDO.[1] Based on this documentation and the discussions in the meeting, the present series of monographs is devoted to the 21 main issues which comprised the agenda of the Symposium. Each monograph includes a chapter on the issues presented, the discussion of the issues,

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[1] *Report of the International Symposium on Industrial Development, Athens 1967* (ID/11) (United Nations publication, Sales No.: 69. II. B. 7).

and the recommendations approved by the Symposium. Some of the monographs deal with specific industrial sectors; some with matters of general industrial policy; and others with various aspects of international economic co-operation. An effort has been made to make the monographs comprehensive and self-contained, while the various economic, technological and institutional aspects of the subject matter are treated within the context of the conditions generally prevailing in the developing countries.

Since economic, technological and institutional aspects are described with particular reference to the needs of the developing countries, it is felt that the monographs will make a distinct contribution in their respective areas. They are intended as a source of general information and reference for persons and institutions in developing countries concerned with problems of industrialization, and particularly with problems and issues of international co-operation in the field of industrialization. With this in view it was considered that an unduly detailed technical presentation should be avoided while at the same time enough substantive material should be offered to be of value to the prospective reader. For a more elaborate treatment of the subject, the reader is referred to the selected list of documents and publications annexed to each monograph.

The annexes also contain information on the areas in which UNIDO can provide technical assistance to the developing countries on request; a selected list of major UNIDO projects in the respective fields; and a list of meetings recently organized by the United Nations.

It is hoped that the monographs will be particularly useful to Governments in connexion with the technical assistance activities of UNIDO and other United Nations bodies in the field of industrial development.

This monograph has been prepared by the secretariat of UNIDO.

CONTENTS

Dollar ($) refers to US dollars unless otherwise specified.
One cent (¢) equals $0.01.
Gallon refers to US liquid gallons.
Ton refers to short tons unless otherwise specified.
Quart refers to US liquid quarts.
A No. 10 can is $6^{3}/_{16}$ inches in diameter and 7 inches in height.

Metric equivalents of English measures

foot (ft) = 30.480 cm
square foot (ft^2) = 929.03 cm^2
cubic foot (ft^3) = 28.317 dm^3
pound (lb) = 453.592 g
quart (qt) = 0.946 l
gallon (gal) = 3.785 l
ton (t) = 907.185 kg

The following abbreviations are used in this monograph:

ECAFE	Economic Commission for Asia and the Far East
FAO	Food and Agriculture Organization of the United Nations
f.o.b.	free on board
FPC	fish-protein concentrate
ISO	International Organization for Standardization
kWh	kilowatt-hour
MW	megawatt (1,000 kilowatt)
psig	pounds per square inch gauge
PVC	polyvinyl chloride
UNIDO	United Nations Industrial Development Organization

INTRODUCTION

The food-processing industry is important to economic growth and to the health of people in developing countries. Many food raw materials in these countries are not fully utilized, foods are imported, food shortages exist, and diets are inadequate. The emerging countries must develop their food resources more extensively. The industrialized countries cannot make up the food deficits of the entire world and its exploding population.

The benefits from the food-processing industry go far beyond calories and nutrition. Food imports can be reduced or eliminated and food products exported—a two-way economic gain. The larger markets and the higher prices created by food processing stimulate greater and more efficient agricultural production. Employment is increased, not only in the food factories and the fields but also in activities ancillary to food processing. These gains add up to economic progress on a broad, sound base.

Freedom from "slavery" to food production and preparation is the great benefit from the food-processing industry. Efficiently processed foods are relatively inexpensive, and they can save both time and money. Easy-to-prepare products free housewives from drudgery—from spending most of their time preparing food for their families. More than that, an integrated food industry can free entire countries from "food slavery"—from spending most of the national effort and income on food and reduce the portion of personal income paid for food from 70 per cent or more to 30 per cent or less. Time and money saved in this way can be directed to the creation and support of other industries and services, generating economic progress.

It should be appreciated, too, that the quality of processed foods has gradually improved over a long span of years in the developed countries. Many products now equal the culinary achievements of chefs in gourmet restaurants, yet sell at popular prices. Many are used in fine restaurants to save time, labour, skill, and cost of food preparation.

Chapter 1 discusses the general nature of food processing. The preservation of fresh farm products for shipping, storage and consumption anywhere at any season is one of the major functions of food processing. Some types of food factories are thus directly dependent upon agricultural production. Most food factories, however, refine non-perishable raw materials or fabricate them into manufactured foods. Such factories are much more dependent upon markets than on local crops. In a very real sense, the food industry is the lifeline of a country, stretching from the farm to the consumer, and processing is an essential part of this line. Protective, attractive and convenient packaging is a major phase of preparing foods for retail sale. The safety, quality and nutritional values of processed foods are critical factors. Taste is all-important to sales, and food likes and distaste or aversion to certain foods change slowly.

Chapter 2 considers world trends in the food industry. Food factories continue to increase in capacity, automation and efficiency. In retailing, the trend has been to large self-service stores with thousands of packaged products on their shelves. The demand for convenient foods and snacks continues to increase. The development of new products helps to keep food manufacturing dynamic. Ingredients for food manufacturing, such as starches and flours, are being increasingly refined, modified and blended to suit specific processing and product needs and to eliminate operations in the processing plant. Cost-cutting techniques are being applied more and more in the transport of food ingredients and finished products. Dry and liquid ingredients are shipped to processors in bulk and handled mechanically in the plant. Finished products are usually moved as unit loads by powered lift trucks, and transport in big box-like containers is becoming more common.

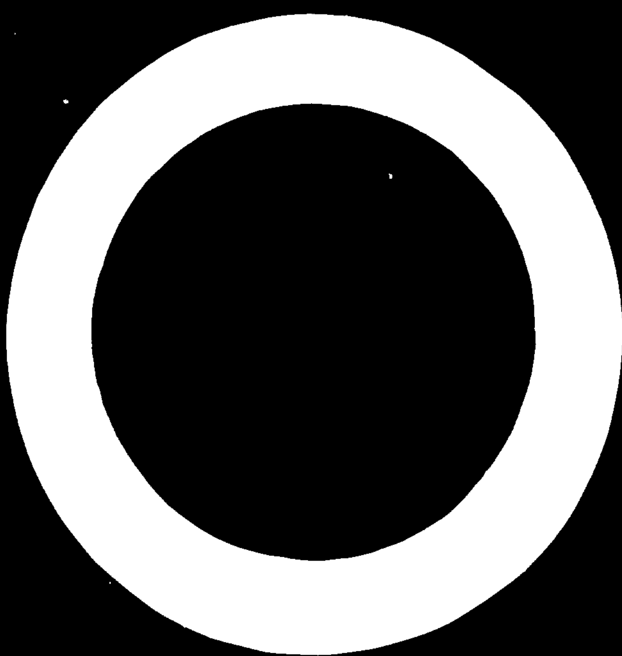
Chapter 3 analyses the major factors to be considered in establishing the food industry in developing countries. Governments must make and keep up to date well-considered, realistic long-range plans to foster and to guide the growth of this vital industry. But before any industry is established, markets for its products must be delineated, both at home and abroad. An organized supply of raw materials of proper quality and in the quantity required for efficient processing is a prerequisite. It is essential to build modern, large-scale, efficient factories capable of producing products of a quality and at a cost competitive in world markets. Production must be sufficient to serve important markets and to justify the high cost of promotion required to open up such markets.

Chapter 4 evaluates a variety of food processes. Efficient, modern processes and equipment are available for preserving and refining most raw food materials and for manufacturing a wide variety of food products. Instrument-controlled dehydration, canning, freezing, smoking, curing and fermentation processes have been extensively proved in practice. Of special significance are new processes to produce protein. One new process isolates protein from soybeans for addition to other foods or for making simulated meats. Another produces protein concentrate from species of fish which are not now eaten although they are fit for human consumption. A third produces protein from petroleum by fermentation. The cooking-extrusion process may facilitate the use of carbohydrate materials such as cassava. The extensive vegetable-oil resources of developing countries can be better utilized through processes and products new to many of those countries.

Chapter 5 discusses the physical requirements of a food factory. Special sanitary construction, an adequate supply of potable water, and efficient waste disposal and by-product recovery are all essential. Good maintenance practices and repair shops are critically important. Special attention must be given to facilities for employee comfort and personal sanitation.

Chapter 6 analyses the key factors influencing investment in the food-processing industry. The industry can operate on a low per-unit profit margin and still realize a fair return on capital investment because of the high volume of sales. The chapter presents profiles of food-processing plants in various countries.

Chapter 7 gives an account of the International Symposium on Industrial Development held in Athens in 1967—the issues, the discussion and the recommendations approved regarding the promotion of the food-processing industry in developing countries. Chapter 8 reviews UNIDO action to promote the food industry in developing countries.



Chapter 1

NATURE OF THE PROCESSING INDUSTRY

GENERAL FEATURES

Some branches of the food industry are directly linked with and dependent upon agricultural production. Perishable commodities, such as fruits and vegetables, wine, olive oil, sugar, milk, meat, fish and poultry require direct processing. Much of today's food industry, however, is supplied by non-perishable materials shipped from a distance, many being intermediate materials purchased from other processors. This applies, for example, to bakery and cereal products, prepared mixes, snack foods, vegetable-oil products (margarine, mayonnaise and salad dressing), beer, carbonated beverages, coffee, syrups, soups, jams and jellies, preserves, condiments, chocolate products, baby foods and others. These items comprise a large percentage of the products of the food-processing industry in developed countries.

For this reason, the food-processing industry today is in general more dependent for success upon the market than it is on close proximity to sources of raw materials. An evaluation of all the opportunities for food processing in developing countries must therefore be based on a study of domestic and world markets. Since different crops can be grown in a given developing country, the question is more what can be sold after processing than what can be produced for processing. This underscores the importance of markets for the food industry.

Food processing originated as a conglomeration of rather unrelated industries based on agriculture, animal husbandry and fishing. Among them were milling, baking, manufacture of other cereal products such as macaroni, beverage bottling, brewing, distilling, cocoa and chocolate processing, confectionery manufacture, dairy products processing, fruit and vegetable canning and preserving, meat packing, fish processing, poultry processing, fats and oils extraction and refining, coffee roasting, sugar refining, salt refining and spice milling.

In the beginning, each of these industries used different techniques and equipment and had little in common. But as processing and its environment became more sophisticated, techniques began to be exten sively interchanged and many common operations and functions wer developed. Today food processing is considered a single industry i developed countries because of its common objectives, problems technology, engineering, regulations, and packaging and marketin methods.

A typical food process consists of several steps. The raw material i received, inspected, cleaned, graded, separated (from peel etc.), cut up or ground, mixed with other food ingredients and chemical additives formed into the desired shape and size, and packaged. It is subjected to heat, refrigeration or dehydration, sometimes is coated and is packaged Fermentation, smoking, curing and extraction may also be employed In a typical process line, material is moved from one operation to another by conveyors or other handling mechanism until the finished, packaged product is transported to the warehouse or shipping platform. Automatic control of process variables, such as temperature, pressure, rate of flow, or acidity is achieved, at least at critical points, by industrial control instruments. In all process operations sanitary conditions and control of product quality must be maintained.

Thus, different types of food processes use similar operational techniques. They also share the food science and technology involved in understanding and controlling the physical, chemical and biological conditions and changes from raw material to finished product. Product formulations for many different foods contain some of the same ingredients and additives. Nutritive value and packaging are of common interest to food processors.

Specialized machines perform certain operations on food materials of different types. While a bread-dough mixer is used only in bakeries and perhaps chewing-gum plants, a ribbon-type mixer can be employed for almost any formulation of dry, free-flowing solids.

The location of a food plant may be determined by the nature of the raw material, the finished product or the market. A plant should be near the source of supply of its raw material when the raw material is highly perishable. A tomato cannery, for example, must be close enough to the fields so that the tomatoes can be transported to it in a matter of hours after harvesting. For prime quality, green peas should be in the processing plant within an hour or so after picking and be frozen or canned within three or four hours.

Slaughter-houses should normally be located near an area where animals are raised or fattened before processing, but a fresh sausage-products plant ought to be situated near its market (in or near a city). Other plants that should be located near their markets to make delivery economic include fresh meat plants, bread bakeries, confectionery plants, milk pasteurizing and bottling plants, and other beverage bottling plants. Cracker and cookie bakeries can be centred in a market region and should be high-capacity plants to achieve maximum efficiency and lowest unit costs. The finished products keep long enough for transport to distant markets.

Many other factors must be considered in locating food plants. Among them are availability of power, water, qualified personnel, housing for personnel, transportation, communications, and waste disposal possibilities. The location of grain mills, for example, may depend on some of these factors.

The food-processing plant is part of the "lifeline" of a country, being a necessary link in the food chain that extends from the farm to the consumer. Processing in a broad sense is a part of marketing. It preserves perishables so that they may be distributed, and it converts raw materials into desirable forms of food. Farmers growing perishable crops usually contract with a processing plant to sell their crops to it. Sometimes a farmers' co-operative owns a plant, but frequently a plant owns and farms a large acreage of land to produce its own raw materials, at least in part. Large retail store chains may also own factories.

An innovation in the grower-processor relationship is a dual farmer-processor co-operative. One such dual organization is now operating in an industrialized country. The farmers, organized into a co-operative, own the processing plant and lease it to a processing-marketing company. Each grower buys an amount of stock in the co-operative proportionate to the size of the crop he wants to sell to the processing plant. A farmer may also buy stock in the processing company and thereby gain a share of its profits.

This type of organization has many advantages, particularly for smaller processors. The benefits may be particularly significant in developing countries having a suitable political and social environment. The combination of growers and processors and marketers has a greater advantage in securing financing than would any of them alone. The dual arrangement permits expert farmers to handle the agricultural phase of the agro-industrial complex, while experts in processing and marketing control handle the business elements. Thus, farmers and the processing company benefit mutually.

In many developing countries the supply of raw materials is ineff ciently organized. Beef cattle, for example, may be in the hands (roaming nomads rather than on ranches and in feedlots. These cattl may change ownership half a dozen times on their way to market, th price being boosted with each change.

In industrialized countries after the food has moved from the farm through processing and packaging, it is stored at the processor's warehous or shipped directly into distribution channels. It normally goes first to (wholesale warehouse or to a manufacturer's distribution centre strategi cally located for serving a large marketing area. At the wholesale ware house or distribution centre, food products are assembled to meet orders from retail stores or restaurants and delivered to buyers by truck. Some distribution centres also perform some packaging operations, such as labelling canned foods, because they can operate on a larger, more efficient scale than can individual plants.

Sometimes the processor delivers directly to stores buying large quantities. Beverage and milk bottlers and bakers customarily deliver directly. Manufacturers' salesmen or sales representatives sell processed foods to wholesalers, retailers and restaurants. Sometimes special food-service marketing organizations sell to the restaurant trade. Such a direct and efficient movement of processed foods to the market will not be found in most developing countries. Marketing practices found in developed countries will probably have to be modified when an integrated agro-industry is established in a developing country.

PACKAGING—A MAJOR OPERATION

Foods must be packaged in order to measure out a suitable quantity for sale to consumers, to protect the foods against contamination and insect infestation, to make them easy to handle and store, to identify the product and its ingredients, and to promote the sale of the item when shoppers see it on the shelves of self-service stores.

After they have been filled and closed, cans, jars, bottles or cartons of the product are assembled in corrugated paperboard shipping cases, usually 24 or 48 to the case. These cases are then stacked in "unit-loads", usually on wooden platforms (pallets) that may be lifted and transported easily and quickly to the warehouse or into a truck or railway car with an industrial lift truck. High-capacity plants assemble unit-loads mechanically with automatic palletizers. Practically all packaging operations are now performed at high speeds by machines, including casing before palletizing. Otherwise the amount of labour required in the packaging department of a food factory would often be far greater than that needed in processing the product. This would make the product too high-priced to be competitive on the mass market. Mechanized packaging also has the advantage that food is untouched by human hands.

The contract packaging company, a fairly new type of company, packages products delivered to it by processors. This arrangement makes it unnecessary for the processor to invest in packaging machinery. It is particularly beneficial when a new product requiring different packaging is introduced by the processor, especially until the product has proved successful in test marketing. Some fruit and vegetable canners put beverages into cans on a contract basis.

A variation of contract packaging is the co-operative packaging of a product produced by a number of processors belonging to an organized group, such as a parent company. In New York State, United States, several bottlers of a certain soft drink, for example, set up a co-operative plant to put their beverage into cans. The investment in equipment was much smaller than it would have been if each bottler had installed his own can-filling line.

Innovations in packaging machines, materials, containers and closures are continuously being introduced. Although cans, glass jars and bottles still are basic for wet foods and folding paperboard cartons for dry foods, dry items are increasingly being put into packages made of flexible plastic film, aluminium foil, or laminations of such films or of the films and foil with paper. Simple flexible-film packages are relatively inexpensive. They can be automatically formed, filled and sealed at high speeds on relatively simple machines in the processor's plant. Their light weight makes them economical to ship. Acid, wet products, like pickles in brine, can be packed in heat-sealed, flexible containers; acid products spoil less readily than non-acid ones.

Pasteurized whole milk is now being packaged in many countries in strong polyethylene bags costing only about half a cent per quart. Starting in Western Europe, the idea has spread to Canada and Brazil and is just penetrating the United States. About 500 installations of machines for forming, filling and sealing the milk packages have reportedly been set up. This type of packaging merits particular consideration in developing countries. Pasteurized milk is also filled into returnable plastic gallon and half-gallon containers, and these can be made in the dairy plant by automatic machines at reasonable cost. Bulk quantities of

pasteurized milk are poured into 10-quart flexible polyethylene b
which are inserted into corrugated paperboard containers for shipm
and delivery. In the United States, by far the largest quantity of mi
filled into paperboard cartons coated with a mixture of polyethy
and wax. These cartons have largely replaced bottles.

Food has been "canned" and heat sterilized in laminated, flex
plastic-film-foil packages in Western Europe. The film is expensive,
if researchers can solve the problem of leakage, the container should
considered in developing countries. Factories to fabricate the film are
expensive than plants making metal cans. The newest way to pack
edible oils, mayonnaise, salad dressing, vinegar and whisky is in plas
bottles. Polyethylene is used in the cheaper containers, but rigid, hig
transparent polyvinyl chloride (PVC) is coming into use where appeara
is important.

For shipment from the intermediate to the final processor (e.g. fr
miller to baker), bulk bins and bulk truck-trailer and railway cars ha
largely replaced bags and drums. Dry materials are unloaded into t
plant pneumatically and liquids are transferred by pumping. Flour, sug
and malt are transported in special bulk trailers and cars. Liquid ing
dients, such as vinegar, shortening and liquid sugar are shipped in ta
cars and tank trucks. Modern food factories are equipped to receive su
large-volume ingredients in bulk and handle them mechanically. Portab
aluminium and plastic bins and large collapsible bags may be used wh
smaller quantities of bulk materials are being transported. These a
handled by lift trucks. Alternatively, bulk materials in smaller quantiti
may be put into protective and sanitary polyethylene bags, which in tu
are packed in corrugated shipping cases and metal or fibre drums. It
even feasible by one process to fill sterilized tomato paste, banana pure
or other such bulk fluid product aseptically into 55-gallon metal drum
so that the product remains sterile during long-distance shipment an
storage. Banana puree is shipped in this way from Honduras to th
United States. One-trip, plastic drums are now coming into use fo
flavouring materials.

Chocolate-flavoured milk drinks, sauces and many other heat
sensitive foods requiring sterilization are aseptically filled into cans afte
being sterilized in a continuous, short-time, high-temperature process
Many plants using this process have been installed in Western Europe
and the United States.

To reduce the amount of packaging material needed and to cut trans
port costs, food products are often concentrated. Evaporated milk

condensed soups, and citrus concentrates are examples. Dehydrated foods are concentrated to the maximum.

In view of the many changes taking place in packaging, it is clear that this phase of food processing should receive almost as much technical consideration in developing countries as the process itself.

Quality Control, Sanitation and Nutritional Standards

Since food for human consumption must be 100 per cent safe, it must be prepared with the utmost care. It must be protected from contamination from whatever source (e.g. pesticides, unsafe chemical preservatives). It must not be permitted to become contaminated with micro-organisms that may cause illness or death, such as *E. coli*, *staphylococcus*, *salmonella* or *botulinum* bacteria. No new additive should be used unless proved safe by research and approved by regulatory agencies. Even "safe" additives can be present only in limited quantities normally employed by the industry or approved by regulatory authorities.

Pasteurizing, as in processing milk, or sterilization, as in canning meat, fish or vegetables, must be strictly regulated. Automatic time-temperature controls are important. Time requirements for thermal killing of micro-organisms must be safely met. Human error cannot be tolerated in these processes. Critical packaging operations, as in applying lids to cans containing food to be heat-sterilized, must be carefully watched. Can seamers have to be kept in good repair and adjustment. A faulty seam may permit micro-organisms to grow that spoil the food or make it unsafe to eat. Sterilized cans should be cooled in chlorinated water to avoid contamination of the contents, and the cans must be handled gently to avoid the seam's springing open and admitting bacteria. Keeping can-handling equipment sanitary is essential.

Quality control and sanitation in the food-processing industry are of the utmost importance not only to protect consumers but also to retain product quality and avoid loss of business through consumer dissatisfaction. Food processors must retain their customers or go out of business. It is to their interest to avoid lawsuits or regulatory penalties and adverse publicity. The quality of the product should be uniform in all packages. The same brand and grade should always look, smell and taste the same. Otherwise customers may think that something is wrong with the product, even though the fluctuating quality remains above average. Each Grade—A, B or C—must be carefully quality-controlled at its level.

Part of the food processor's responsibility is to "sell nutrition his customers. He should be sure that his products have the expe nutritional values. He should also consider the special requirement different groups. To meet the need for more protein in the diet in m developing countries, certain products might be enriched with prot For instance, bread can be formulated with the addition of lysine, s flour, or fish protein concentrate. When a substitute food is offered nutritional value should be as high or higher than that of the f replaced. Thus, margarine, a substitute for butter, is vitamin-enricl

If processors in developing countries are to export foods, tl products must be processed and packaged under conditions that meet sanitary and quality standards maintained in the importing countr Their processing plants may have to undergo the same inspection tha carried out in food factories in the importing countries. The process must meet the standards of identification, quality, container-fill a labelling existing in the importing countries or established by the int national *Codex alimentarius*.

FOOD HABITS

Most people eat a particular food because they like it. Even hung and malnourished people tend to select foods that taste good to the rather than those that are better nutritionally but not so enjoyab Thus, foods must be so formulated, processed and packaged as to appe to taste. This also means that these products must have the textur mouth-feel, colour and aroma that consumers prefer. No processor ca risk trying to sell a food product using only the argument that it is goo for the health of the consumer. A nutritious product must also tas good. To be sure, nutritional value adds to the appeal of a product.

A competent chef and a food scientist or technologist must b involved in the formulation or modification of a processed food. The the new or modified product must be carefully tasted not only by taste-panel but also by potential consumers. Before commercial produc tion begins, market testing should be done on a fairly large scale. Onl after the product proves desirable and its price acceptable in such a tes can production, distribution and promotion on a commercial scale b risked.

Thus, caution must be exercised in changing popular foods ir developing countries to improve their nutritional value. Althougl improvement is highly desirable and much can be achieved, experience shows that any slight change in taste, colour, aroma or texture may lead to rejection of the improved product. Certainly any price increase resulting from improvement will curtail consumption.

In evaluating the potential of food markets in developing countries, the traditional slowness with which people in these countries change their food habits must be considered. New or even modified foods must be introduced in the most appropriate way. A study of changing food habits in developing countries based on case histories and interviews with advisers in the field has revealed some of the difficulties in introducing new foods.[1]

Although great numbers of new foods and new eating habits have been adopted by different cultures throughout history, it traditionally took decades, even centuries, to accomplish such changes. Unfamiliarity is one of the most common reasons for rejecting new foods. Negative feelings occur when the individual is exposed to what he considers "improper" foods; "proper" foods elicit positive feelings. North Americans, for instance, are strongly averse to eating insects, which are relished by many other peoples. South East Asians do not drink liquid milk, but Europeans drink a great deal of it.

Taste preferences may result from economic necessity. The poorer peoples of the tropical countries, for example, depend heavily on low-cost. starchy foods. This is particularly true of rice-eating peoples, who have developed a taste for a little meat with plenty of rice. Some food biases are based on habit. Villagers in some countries will not eat vegetables introduced from outside.

Proponents of change cannot ignore religious concepts or beliefs. Orthodox Jews, for instance, do not eat shellfish or fish with scales or gills. The Islamic prohibition against eating pork and the Hindu belief that cows are sacred are well known. Folklore or superstition may play a role. White Yorkshire hogs, introduced to improve pork production in a country in which white is the colour of mourning, frightened the inhabitants.

Cost is probably the greatest barrier to acceptance of new foods in developing countries. The length of time necessary for preparation is also a factor. New breeds of maize have been rejected or used for other

[1] "Changing Food Habits", *Journal of Nutrition Education*, summer 1969; published by Society for Nutrition Education, University of California, Berkeley, Calif.

purposes because they require more labour in grinding. Milk, usu powdered, has caused more evident physiological reactions than other type of food newly introduced. Children have become ill fr eating the dry milk powder. When reconstituted with unboiled water, milk has caused stomach aches and diarrhoea. The introduction of su new foods must be accompanied by education and demonstration of proper preparation and use.

The key to acceptance of change is the perception by the individ of the advantages to be gained from it. The change-agent's success l in augmenting and supplementing an existing local cultural pattern, n in replacing it. Children are always more willing to try new foods th adults. They have not developed the strong and emotionally support biases of their own cultures as have their parents. If prestige can attached to a new item, the item may be accepted quickly.

Chapter 2

WORLD FOOD TRENDS

There is a strong trend in food manufacturing towards building larger and fewer factories to keep unit costs down through highly mechanized, automated, high-capacity production. This trend should be followed in developing countries. Small processors need to produce something special with respect to type of product, quality or service to justify the higher price resulting from inefficiency.

In retail distribution the trend has been towards establishing large self-service stores, or supermarkets. This trend is extending even into the larger cities of developing countries. Customers like to see nicely packaged foods displayed on the shelves, and they benefit from the low operating cost of the supermarkets. The average profit margin of supermarkets carrying some 8,000 food and non-food items is not over 1.5 per cent on the sales dollar in one industrialized country. Similarly efficient, low-cost retail operations are needed on a large scale in developing countries in order to minimize food prices.

Food companies in developed countries keep business dynamic by continually introducing new products and packages or variations of existing ones. The product trend is towards more and more convenience items, snack foods, and foods with gourmet quality, such as peas canned in butter sauce. This trend is important to food-export businesses in developing countries. Another trend is towards the processing and packaging of prepared or semi-prepared foods in controlled portions for restaurants, hospitals and other institutions. These prepared foods, sometimes in individual-portion packages, reduce labour and other costs in all types of food-service operations. They enable a small restaurant to have varied menus and to serve high-quality dishes without an expert chef. They ease the feeding problem in hospitals, schools and factories.

To meet the requirements of the self-service market, the restaurant, and today's convenience-minded consumer, packaging must be sophisticated. Some restaurant dishes are packaged in thin-gauge aluminium trays that may be placed on steamtables; many items, from sugar to syrup, come in little one-portion containers made of plastic, pa foil, efficiently formed, filled and sealed by high-speed automatic mac and beverage cans have a pull-off lid that makes a can-opener un sary. Convenience and quality at a fair price—these are the keys to s in food processing in markets where people have more than a subsis income. They must be considered by those wishing to export fo developed countries.

The use of vending machines for food products has been ste increasing in industrialized countries, and products are espe processed and packaged for this market. Vending of hot foods (h by the vending machine) is gaining importance. Machines are built refrigerated storage for beverages and frozen desserts. Confec cookies, small cakes, snacks, coffee and soft drinks are the le vended foods. Vending by machine is an efficient and convenient n of serving food in lunch rooms in factories and office buildings. It be supplemented by manual vending of a few items.

These trends will inevitably influence food processing for e from developing countries and in some cases domestic food mark as well. However, the domestically oriented phase of food processi the early stages of the development of a country is usually conce with processing low-cost staples, such as milling grain. As incomes there is a shift towards more expensive foods, such as meat, milk, fish, fruits and vegetables. Sometimes one or more major cities developing country will have a sufficient number of residents who afford the more expensive food products. This offers opportunitie processing such foods on a limited scale. Even the poorest countries a reasonable number of people with relatively high incomes who either imported foods or domestic counterparts if available. That is native entrepreneurs can establish soft-drink plants, breweries, bak and ice cream businesses in cities with populations numbering se thousand.

In developing countries exporting raw food materials, there trend towards more local processing and exporting of finished prod In recent years, for example, some of the coffee-producing countries installed soluble-coffee processing plants. Now they ship to their for coffee-bean customers abroad a high-value added instant coffee. A opportunity may arise for developing countries that export black te be used in making instant tea. If research makes it possible for powd tea to be made directly from green tea leaves, local processors w benefit from an export item with considerable value added; the product might even have a superior flavour, since some flavour is lost in the black tea process.

Another trend is towards concentrating products that must be shipped considerable distances. Such products include condensed soups, evaporated milk, and juice concentrates. Powdered juices and powdered milk are examples of products concentrated by the maximum amount. Concentration produces tremendous savings in packaging materials and in shipping costs.

The modern food industry is increasingly using more sophisticated intermediate food materials as ingredients in product formulation. This simplifies processing and saves time, labour, floor space and investment in formulating and mixing equipment. Pre-blended flours for bakeries offer such advantages, as do mixtures of salt and other small-quantity additives. The list of refined and sophisticated ingredients purchased by food processors from other food processors is a long one. Cheeses now come in powdered form. Powdered milk and powdered whey are processed to suit users' requirements. (Powdered whey may be demineralized by electro-dialysis.) Starches have been broken down into a great many different types tailored to specific uses.

For economic reasons ingredients are increasingly being shipped in bulk instead of in bags, and food is being handled in bulk by liquid and pneumatic conveying systems in the plants. Cost-cutting techniques have been developed in the physical distribution of the finished products. Cases of finished products are placed on pallets that are moved and stacked by powered lift trucks into railway cars or trucks or into the factory warehouse. A trend is under way towards "containerization" of pallet loads of cased foods. Containers measuring, for example, $20 \times 10 \times \times 8$ ft can be filled with many pallet loads of products and handled mechanically as a larger unit. Containers can be hauled by tractor-trailer, by railway, by ship and even by airplane. Major shipping ports around the world are being equipped to handle containers. For shipment of chilled or frozen products, containers can be refrigerated by liquid nitrogen or by mechanical means. Economies in shipping are achieved also by hauling tractor-trailer loads of food products on flat railway cars and on the decks of freight ships.

Bulk dry materials are readily transported in special railway cars or in tanks on tractor-trailers equipped for pneumatic loading and unloading of the material. Special freight cars for dry material have

built-in aeration systems for fluidizing powdered material so tha
flow to discharge hoppers. Liquids in bulk are transported in t
railway cars, truck-trailers and ships. Modern facilities for tran
food materials and products by land and sea should be the
investigated by agro-industrial entrepreneurs when evaluating ma
opportunities and costs.

Chapter 3

MAJOR FACTORS TO CONSIDER IN ESTABLISHING THE FOOD INDUSTRY

For Governments of developing countries, well-considered, practical long-range plans for the food industry are essential. A master plan should be drawn up for the establishment of an agro-industry of the type and capacity needed and feasible. The plan should encompass ancillary facilities to the extent that these are economically justified. The result will be an integrated agro-industry that involves a maximum amount of exports and domestic business, and a minimum of imports. Such integration puts processors in a stronger position to compete in world markets. In their long-range planning, developing countries should make accurate evaluations of local food needs, export possibilities and agricultural opportunities. They must even decide how much of their productive land will be devoted to food and how much to fibre and other non-food uses.

When the Government of a developing country does not have a sound long-range plan for the development of the food-processing industry, the entrepreneur is wise to move cautiously. He must consider government attitudes towards business, taxes on industry, freedom of management to operate its business, and restrictions on taking profits out of the country.

Markets

When processing opportunities in developing countries are being evaluated, a number of factors must be considered. The market deserves first attention. It is necessary to define the potential market for the products to be produced. Regional markets including two or more nearby countries should be developed whenever feasible, in addition to local markets and distant export markets.

Many questions must be answered by sound surveys. Among them are:

Do people in the cities have sufficient income to buy the product?

Does the item fit into traditional eating habits and taste preferences ?

Does it conflict with any personal, social, or religious principles or behaviour ?

Is there a need and a desire for the product or for its nutritive value ?

Are other products of the same type strongly entrenched in the market, either domestic items or imports ?

Is the product competitive in price and quality with similar items that are available ?

Do facilities exist for marketing the food efficiently ?

Will the promotion funds and the volume of production of the product be large enough for successful development of the market potential ?

Food and beverages can be processed for the domestic market as substitutes for imports—or sometimes as innovations—even if some raw materials have to be imported. Imported ingredients such as flour, fat, flavour concentrates and malt can be used in the production of baked goods, ice cream, soft drinks and beer, and these items can be sold successfully in the larger cities. Processed foods using imported raw materials substitute for finished-product imports, and their production creates employment and otherwise helps the economy. Some export to neighbouring developing countries may also be feasible.

The criteria for evaluating export demand are severe. In the export field competition is keen, so quality and packaging standards must be especially high. But the buying power is there, so that it is advisable to export high-quality or specialty foods that sell for a relatively high price. The history of the food industry has amply proved that high quality at a reasonable price is the surest and quickest way to success where consumers have discretionary buying power comfortably above the subsistence level.

Supply of raw materials

The supply of raw materials must next be examined. The supply must be adequate, organizable and dependable. Materials must be of a variety suited to processing, of sound quality, and be geographically concentrated sufficiently for exploitation. Fruit trees scattered throughout thousands of jungle acres are of little practical value, for example; the trees must be concentrated on plantations. Surplus production from scattered vegetable farms of one or two acres is worthless to the processor. What is needed is concentrated vegetable-growing on a scale and of a quality commensurate with processing requirements. Cattle grazing in nomadic fashion over wide reaches of land are of little use to the meat-packer or to the manufacturer of dairy products. The supply is too unorganized, uncertain and remote. The packer needs cattle farms and feedlots, and the dairy products manufacturer requires compact herds of quality-bred milk cows. Many food-processing projects have failed in developing countries because the factory lacked an adequate supply of the proper raw materials.

In many countries transport to move raw materials to factories (and products to market) is inadequate. Insulated and refrigerated trucks and railway cars are usually scarce or non-existent, and refrigerated warehouses may be unavailable. The roads may be poor. The situation varies from country to country. In some countries transport is being modernized.

Processing facilities

When new food-processing plants are being established in developing countries, modern facilities must be installed. Then uniform-quality products can be produced under sanitary and technically sound conditions, at the lowest possible unit cost, and with minimum dependence upon the skill of workers and supervisors. Such products can compete in both domestic and export markets with products from developed countries.

Industrial food-processing must be a sound business enterprise. This is not to say, however, that small-scale, mostly manual food-processing for local consumption should not be encouraged in rural areas. Simple, basic, do-it-yourself processing equipment ought to be available in countries where people on small farms and in villages are short of food and do not have enough income to purchase commercially processed items. Such rural equipment might include simple grain mills, open kettles for boiling and concentrating fruit or cane juices or rendering animal fat, smokehouses for fish and meat, and racks for sun-drying various foods.

Community-size facilities, even a neighbourhood cannery, could be utilized for maximum local production if small co-operative groups were organized. A community cannery with equipment for preparing fruit and vegetables, devices for closing containers, and sterilizers has been developed especially for such situations by at least one manufacturer. And the concept has been applied successfully in extremely low-income mountain areas of a developed country. Pressure sterilizers small enough for individual family use are also available. Such do-it-yourself food processing is an additional step in the development of a country and is a great help in an emergency. It supplements in an essential way industrial-scale food processing until people in rural areas have cash incomes, or are so situated that they can exchange raw foods for processed items at a retail store or small custom-processing plant.

Food processing on an industrial scale should first be considered for leading domestic staple foods and crops, such as rice, millet, cassava, sugar-cane, bananas, coffee, tea, cocoa, tropical fruits and vegetables, nuts, oilseeds, fish and spices. Procedures and equipment for processing many of these materials can be obtained from developed countries. To process on an industrial scale products not normally processed at present, such as cassava and many tropical fruits, further research and development will be necessary.

A factory should not be built before the feasibility of the process has been established. Yet it should not be assumed that processes employed in developed countries will not be satisfactory in tropical developing countries. If the raw material is essentially the same, the process will be basically satisfactory. Shrimp, for example, are just as readily deveined, peeled, packaged and frozen in a modern plant in South America as they are in Denmark.

NEW MATERIALS AND PRODUCTS

In developing a country's food potential, special consideration should be given to introducing new sources of food. One is poultry farming, for which extremely efficient industrial production techniques have been soundly established. Poultry can be raised quickly and with a relatively high ratio of meat to feed. Chicken is nutritious, relatively low-cost, and widely liked. Fish farming in natural or artificial inland lakes or ponds is another potential new source of high-protein food. Catfish, for example, are produced with an especially economical ratio of feed to meat. Producing and processing soybeans as a source of protein for food and for animal feed certainly merits careful investigation. Soybeans can be grown in many parts of the world; their protein is of a relatively high quality; their oil can be used in manufacturing many products, notably margarine; and their protein can be isolated to enrich foods and to make simulated meat.

Bread is reported to be gaining acceptance in developing countries faster than any other food product. It is a wholesome staple in the diet, is widely liked even by many peoples who have not eaten it before, is low in cost relative to its food value, versatile in its uses, and can be economically enriched with protein, vitamins, and minerals to meet dietary deficiencies. Introduced into major cities in India a few years ago, bread production is now reported to be unable to meet demand.

Personnel requirements

A serious problem in establishing the food-processing industry in developing countries is the shortage of management and technical personnel, as well as skilled mechanics. Attention must be paid to obtaining or training qualified people. Entrepreneurs and managers capable of developing and directing a business enterprise dynamically are not easy to find anywhere. Such men are likely to be in the employ of existing food manufacturing companies.

No food factory and no food-processing line should be designed without the participation of an experienced food scientist or technologist, nor should any major piece of processing equipment be selected without approval by an expert. Equipment must be not only mechanically well designed and constructed but must also effectively perform a food-processing function affecting the physical, organoleptic, chemical or biological qualities of the food. The equipment must be sanitary and easy to clean, must withstand corrosion from food acids and alkaline cleaners, and must not contaminate the food either with traces of metal that harm quality or with micro-organisms from minute cracks, pores or dead-end pockets.

Once the average food plant is operating, trained practical personnel can supervise it provided they are conscientious and dependable. But when problems concerning sanitation or the quality of the food arise, a consulting food scientist should be called. Even routine quality testing and control can be taught to technicians after procedures have been established by a scientist. Likewise, an engineer should set up procedures for operating and maintaining the equipment and then train personnel to follow these procedures routinely. Local unskilled people can usually be trained to handle skilled jobs, including even engine repair. This has been demonstrated on many occasions, as at the new solar salt plant in the Bahamas.

It may be necessary to import technical talent, at least at the outset. One way to fill a technical gap quickly may be to hire a chemical engineer, preferably in the country concerned, and send him to a food technology school for instruction in the biological sciences. Even without such training but with knowledge gained from textbooks, a chemical engineer can handle most of the technical problems of food processing. At least he can recognize the problems and know where to find the answers.

Costs

A substantial investment of capital is necessary to establish a modern, efficient agro-industrial food-processing and marketing business. This is one of the greatest obstructions to the growth of such enterprises in developing countries. The cost of importing food-processing equipment may increase the fixed capital requirements of plants in developing countries. This will vary by country, depending on shipping distances and tariffs. To finance machinery purchases, processors can arrange with the makers of equipment in some countries to accept at least partial payment in the product to be produced by the plant. The best machines may not always be obtainable in this manner, however.

Importing cans and glass containers is expensive. The manufacture of such containers is to be encouraged in developing countries as soon as demand justifies the investment, if the materials are available at reasonable cost.

EVALUATING FOOD PROCESSES

METHODS OF PRESERVING FOOD

Dehydration, salting, fermentation, pickling and smoking have particular advantages in countries where refrigerated transportation, storage and distribution facilities are non-existent or limited. Dehydration is a traditional way of preserving fruits, vegetables and meat in the tropics and sub-tropics. Canning and glass packing are also excellent methods of preservation where there is no refrigeration, but it may be difficult to obtain the containers locally and they are expensive. For exports, especially fish and seafood, freezing at port of shipment is sound.

Conventional hot-air tunnel dehydration is one of the least expensive methods of food preservation. Sun-drying is still cheaper, but not so sanitary or controllable, nor is it protected from unexpected rains. Drying fluids by concentrating them in an evaporator and spraying them into hot air is economical, and the cost of equipment relatively reasonable. Drying by flowing the fluid over a heated revolving drum is even less expensive. Drying under vacuum at reduced temperature protects heat-sensitive quality, but is costly.

Freeze-drying (drying frozen food under vacuum by sublimation) is too expensive as yet for anything but a premium-price product such as shrimp, top-quality instant coffee, or ingredients like cubes of chicken, beef or mushrooms for soup mixes to be used as a small portion of total content. In addition to protecting taste quality in heat-sensitive foods, freeze-drying makes it possible for the frozen pieces to retain their approximate size and shape, and it makes the pieces porous like a sponge for quick rehydration. Retention of the shape of dried pieces of meat, chicken and mushrooms in dry soup mixes is important from the point of view of consumer preference.

Foaming a *purée* and then drying it to produce porous, instantly soluble particles (foam dehydration) is too new to have become well established. Explosion-puff dehydration, used for drying diced vegetables to make them porous for quick rehydration is also new. It involves removing about half of the moisture from the diced pieces in a conventional hot-air tunnel dryer, puffing them in a quick-pressure-release "gun" to open the structure, then drying them in the hot-air tunnel. Foam and puff-drying are less expensive than freeze drying.

A new method for continuous vacuum-drying of whole milk foam has just been successfully tested in a pilot plant. The milk is foamed with inert gas (nitrogen) and then dried on a travelling stainless steel belt in a vacuum chamber. The dryer is a modification of one long used to vacuum-dry soluble coffee and concentrated citrus juice.

Flash dryers have been applied to vegetable, fruit and cannery wastes, especially peel. Gas-heated air is forced up through a bed of the wet material to fluidize it and obtain circulation of the hot air around all pieces. As pieces become dry they are buoyed up in the air stream and finally discharged from the dryer when their moisture content and density have been reduced to the desired level. The technique of fluidizing the bed of material is also used in the more conventional types of hot-air dryers, the air being blown up through a wire-mesh belt. Still another variation is air-through-product drying on an up-slanted conveyor that causes the product to tumble backward until its moisture content and density have been reduced sufficiently. A tall tower dryer has been developed in Europe that sprays a liquid product into desiccant-dried air of ambient temperature for gentle drying during a long drop. It is not widely used as yet.

Dehydrated foods are light in weight and can be transported and distributed economically. It is difficult to dry cuts of meat like steaks and chops and poultry meat without making them tough and slow to rehydrate unless by freeze-drying or by shredding, drying and re-assembling the fibres.

When liquid foods such as milk are spray-dried, the modern practice is to "instantize" them by agglomerating the particles into larger sizes so that they will quickly go into solution in water. Food processors use large quantities of powdered milk and powdered eggs as ingredients. Consumers also use large amounts of powdered milk, which is commercially reconstituted into plain and flavoured fluid milks in many parts of the world where fresh milk is in short supply.

For canning and glass packing, fruits and vegetables are trimmed, washed, sorted, inspected, sometimes depodded, pitted, cut and blanched, then filled into cans or jars along with brine or syrup. Then the lids of the containers are sealed hermetically and the containers are heated in water or in steam under pressure, in a retort or hydrostatic cooker, to kill micro-organisms that cause sickness or spoilage. This process usually changes the taste from "fresh" to "cooked". Canned and glass-packed foods are wholesome and nutritious, are well liked, and are convenient. In some countries with limited refrigeration, bottled fluid milk is sterilized in hydrostatic cookers to preserve it.

Canning is the oldest modern process for preserving foods and therefore long proved in practice. Equipment for canning is readily available. Efficient continuous, high-output retorts and coolers with automatic controls have been in operation for some forty years. Continuous, high-capacity hydrostatic sterilizer-coolers have been used for more than twenty years.

In the retort, steam under pressure in a closed chamber boosts temperatures to 240° F (116° C) or higher. In the hydrostatic cooker, steam is held under pressure by tall columns of water through which cans are conveyed vertically into and out of the sterilizing steam. These are high-capacity cookers and are economical in their use of steam, water, floor space and labour. For canning on a smaller scale, batch-type retorts are employed. Both the continuous retort-cooler and the hydrostatic cooker-cooler should be considered for large-scale industrialized canneries in developing countries.

Quick-freezing of products, especially fish and seafoods frozen at dockside for export, is an excellent process for developing countries. Quick-freezing has been done for more than forty years, so it is a well-established process using proven equipment and technology. The most economical type of quick-freezer blows air at a temperature of −30 to −40° F (−34 to −40° C) over and around the product as it is conveyed through a tunnel on a belt or on racks before or after packaging. The cost of freezing is about half a cent per pound. Freezing after filling into cartons is often done by inserting the packages into a contact plate freezer for fast heat transfer. Expensive foods, such as shrimp, are sometimes frozen cryogenically in a spray of liquid nitrogen (−320° F, or −196° C). Immersion freezers, in which the product or its container is in direct contact with refrigerated salt or sugar solution or alcohol, may also be used. Heat transfer is fast, and whole dressed turkeys may be frozen by immersion.

An interesting new development, in commercial use for over a year, is a continuous liquid Freon (—22° F, or —30° C) freezer. It freezes individual, unpackaged breaded shrimp in 7 to 8 minutes at a cost of about 1 cent per pound. Flavour is frozen-in and yield is increased because less dehydration occurs in unpackaged shrimp than in an air-blast freezer. The product is frozen by immersion and spray, or spray only for shrimp. Liquid Freon vaporizes as it absorbs heat from the food, the vapour being condensed by a conventional refrigeration system for reuse. The food-grade Freon is nontoxic, tasteless, odourless and safe to use. For every 100 pounds of product frozen, about three fourths of a pound of Freon is lost by being carried out of the freezer on breaded shrimp, from which it subsequently escapes.

Preservation of many foods is possible with a variety of chemicals such as salt, sugar, nitrate and nitrite, various acids, alcohol, and chemicals in smoke. Salt in foods, if present in concentrations of 5 per cent of the weight of water, preserves fish, meats and sausage. The salt is aided in meat by the nitrates and nitrites. Vinegar (acetic acid) is a common preservative; so also are benzoic acid, sorbic acid, lactic acid and propionic acid. Application methods and amounts needed and permissible are well established; excessive amounts of nitrite can be deadly.

Fermentation is used in developing countries to produce a variety of products ranging from tempeh (soybean base) to beer, wine, yogurt and cheese. Careful technical control is required to produce a stipulated quality uniformly for commercial marketing. Meat and fish can be preserved and flavoured by smoking; the heat applied dehydrates the product, and the smoke deposits chemicals on its surface.

Antibiotics have been used experimentally, and to a very limited extent commercially, to extend the shelf-life of foods. But this method is not sufficiently perfected or dependable to be recommended for developing countries. Ionizing radiation emitted from radioactive materials or generated by electronic devices will preserve food. Unfortunately, doses heavy enough to prevent spoilage sometimes change flavour, texture, colour or odour of the food. Pasteurization doses may not damage the product and can extend the time it will keep by destroying micro-organisms on the surface. A light dose kills insects and larvae in grain and inhibits sprouting of potatoes and other root vegetables, thus extending storage life. Radiation extends the fresh-life of fruits, berries and fish by killing mi ro-organisms on the surface. Although radiation may some day find many specialized applications, it is not now ready to be applied on a large scale in developing countries.

High-frequency electromagnetic waves (microwaves) will very quickly heat most food products throughout their mass. Only minor use has been made of this heat source, however, in food-processing. Final dehydration of potato chips after coo ing in hot oil is a sound practice.

Pre-cooking of cut-up poultry continuously with microwaves prior to freezing has been done commercially in one plant. Frozen ingredients such as liquid eggs or fruits can be thawed in a microwave oven quickly and without growth of bacteria. Microwave heat is relatively expensive, however, and maintenance of equipment could be a problem in developing countries. Heat processing under infra-red electric lamps or gas-heated refractories is convenient for conveyorized processing, such as dehydration, cooking and baking. Control of the heat source is easy and accurate, and the instruments required are simple.

Obtaining salt by evaporating sea-water through the action of the sun and the trade winds is a process peculiar to the tropics. The latest such installation is in the Bahamas. Sea-water is held in large-acreage concentrating ponds on land for many months, then pumped into crystallizing ponds and held until the water evaporates and leaves salt.

Advanced technology is contributing to higher quality and efficiency. New techniques include instrument-controlled, continuous-flow processes; short-time exposure of food to high temperatures—as used in pasteurization of milk, in sterilization of canned foods, and in evaporation, as in concentrating juices; and aseptic canning of the pre-sterilized product. Developing countries should take advantage of these advances.

TOP-PRIORITY PROCESSES FOR PROTEINS, CARBOHYDRATES, OILS AND FATS

Most developing countries are short on protein foods, long on carbohydrate products, and well suited to the production of oil-bearing seeds, beans and nuts. The application of new and advanced processes to food in these categories is not only logical but also urgently needed. Adequate markets and distribution channels must be foreseen, however, before large-scale enterprises are inaugurated.

Proteins

In their long-range planning, Governments must decide how much improvement in protein production is to be made through animal products and how much through vegetable sources. The efficiency of vegetable protein production is much greater than that of animal production. Soybean farming, for example, offers good possibilities in many tropical countries. High-protein flour can be produced from the beans for incorporation into native foods. "Soy-milk", a nutritious beverage, can be made from soy powder.

New technology has created challenging opportunities. Protein can be isolated from soybeans by chemical extraction, then spun much like rayon, or otherwise formed into a textured protein isolate and mixed with other ingredients to produce simulated meats. Such "meats" are available commercially: and they look, taste and have the same mouth-feel or chewiness as the beef, pork, chicken, turkey or fish that they simulate. Textured protein can also be added to other foods to enrich them and is an excellent meat-extender. Protein isolation processes are covered by patents, but licensing or other arrangements for transferring know-how to developing countries are probably possible. One company with such know-how is already participating in a joint venture in India.

Production of fish-protein concentrate (FPC) from fish that would not otherwise be widely consumed has also been made feasible by new technology. Fat is extracted from fish with isopropyl alcohol, then the remaining high-protein material is desolventized. A dry powder in its finished form, the FPC is odourless and tasteless; it should be a low-cost protein that can be used to enrich other foods in developing countries. Fish meal has long been used as a protein supplement for animal feed. An FPC process developed by the United States Bureau of Commercial Fisheries is available to developing countries. Another and privately owned process is in semi-commercial operation. FPC has been added experimentally to cereal foods indigenous to Indonesia, Mexico, Peru and South Africa. No difference in taste or texture of the food has been noticed. Guaranteed FPC plants can be erected in a year, and the cost amortized in five years.

Another promising protein development becoming commercially feasible is the production of protein from petroleum by a fermentation process. A protein suitable for use in animal feed is reported to be low in cost. It is more expensive to produce protein for human consumption because it is necessary to refine the protein. Plants that will produce protein from petroleum are being built in Japan, the Union of Soviet Socialist Republics and the United Kingdom, all to produce protein for animal feed. Extensive research is being carried out in this field by leading petroleum companies in the United States.

Synthetic lysine can be used to enrich foods that have low-grade protein. The addition of a few pounds of lysine to a ton of wheat boosts the protein quality to that of casein (the milk protein) at a cost of about $4. Incaparina, a low-cost, high-protein mixture of cottonseed and maize has been introduced in Colombia; enriched with lysine, its protein quality is comparable to that of cow's milk. Although synthetic lysine is considered to be relatively expensive for use in developing countries, it may become cheaper if produced in large quantities. Synthetics tend to become relatively cheaper with time and volume, while the price of natural products increases. Lysine can also be produced by fermentation.

A breakthrough in the development and application of high-protein maize has been achieved. This grain is now grown in Colombia to make a food for infants that costs only 2 cents per serving and will supply all the protein requirements if consumed three times daily. Another high-protein product costing about 4 cents per serving is made from soy flour, cornstarch, skimmed milk, vitamins and minerals. Three one-and-a-half-ounce servings supply most of the daily protein, vitamins and minerals needed by children. A chocolate-flavoured drink made from cocoa beans and soybeans, containing about 3 per cent protein, has been introduced in Brazil. Peanut protein isolate is used in India to make vegetable milk. Added to buffalo milk, which is rich in fat, it produces a beverage with the protein and fat content of cow's milk.

Making edible protein by fermenting carbohydrates such as molasses and maize is in the experimental stage. Another research effort is aimed at converting cellulose waste products such as maize, cobs, grass, leaves, sugar-cane residue, and even logs into protein foods.

The groundnut is a great source of protein in many developing countries. It is almost universally liked in various forms, and it can be used as an ingredient in many other foods. Averaging about 28 per cent protein and 47 per cent fat, the nut is highly digestible, either raw or roasted. A spread or butter, quite popular in some industrialized countries, can be made by dry-roasting and grinding the nuts. The groundnuts can be defatted by pressing out most of the oil, then causing the nutmeat to reshape itself by immersion in hot water. Groundnut oil is one of the most extensively used vegetable oils in the world.

How to utilize the meat produced in some land-locked developing areas presents a challenge to technologists. Export distances are so great for some countries that a low-cost method of dehydration, liquefying or extraction is needed. It would also be helpful to have meat in a form that could be mixed with soy-protein isolate. Perhaps the patented method of shredding poultry meat into fibres, drying the fibres inexpensively in a conventional airblast dehydrator, then reassembling them might be applicable. The fibres could readily be mixed with soy-protein isolate in fibre form for the production of semi-meat products. Another possibility is to liquefy beef by enzyme treatment or comminution for use in baby foods or for low-cost drum drying. Low-quality beef could be economically tenderized by the patented method of injecting proteolytic enzymes into the animal's blood stream before slaughter.

Meat processing can be made much more efficient by advanced techniques. Hydraulic beef-skinning equipment saves labour in slaughter-houses. Meat cutting has been speeded by power-saws and knives. Manufacture of sausage products has been improved by continuous stuffing operations. Frankfurter production has been automated and made continuous from the moulding of the meat emulsion to the cooling of the smoked and cooked product. Removal of casings and packaging have also been automated. Hams, butts and bacon bellies are quick-cured to achieve significant savings in time, labour and floor space by injecting the curing solution into the meat through hollow needles. Retorting canned meat has been automated by time, temperature and sequence controllers. The latest heat-processing technique for meat is pre-cooking of bacon and of cocktail-size frankfurters before packaging them by exposure in continuous flow to infra-red heat sources both above and below the meat.

Computers are used in calculating the lowest cost mixture of meat trimmings that will meet sausage product standards. A computer has even been applied to bologna slicing to assure uniform package weight with a given number of slices. The computer compensates for variations in the density and the cross-section of area of the meat being sliced.

Products with a plastic consistency, such as meat emulsions and processed cheeses, may be formed or shaped and packaged simultaneously. The packaging film is formed around a vertical mandrel and heat-sealed to form a tube of film. Then the bottom is heat-sealed, and the product is introduced through the mandrel into the package as it is lowered from the mandrel. Heat-sealing the top and cutting the package free from the tube complete the operation. The product produced in this efficient form-fill-seal packaging is readily sliced for consumption.

Poultry processing has become a highly integrated, unusually efficient operation. In industrial hatcheries special breeds of birds are grown with a high meat-feed ratio in batteries of coops designed for mechanized cleaning. Then the birds are slaughtered, scalded, defeathered mechanically, and dressed on continuous conveyors. Dressed chicken may be marketed whole or as parts, either chilled and shipped in special iced containers or packaged into cartons and quick frozen, or it may be canned. One processor pre-cooks chicken parts in a continuous microwave oven before quick freezing, or breading and freezing. Advanced poultry packers use automatic ice-making and conveying systems that deliver chip or flake ice on demand to points in the plant where needed for chilling water or ice-packing poultry. Many special poultry-processing machines have been developed in the past several years to eliminate manual operations. Among these are deboning machines used in canning poultry.

In fish processing the trend is to mechanization, starting with pumping fish from the holds of boats quickly, efficiently and without damage and ending with automatic breading and frying of fish sticks. Filleting is done by machine. Before freezing, fish is automatically sprayed with phosphate solution, which not only reduces drip when the product is thawed but slows protein denaturation. Shrimp are deveined and peeled with the aid of machines, and they are graded for size mechanically. Breading is done continuously and automatically, even to the extent of instrument control of the density of the batter used. New methods of quick freezing shrimp involve spraying with liquid Freon (food-grade) or with liquid nitrogen. The former is reported to be somewhat the more economical; both protect quality by ultra-fast freezing. Standards of quality control have recently been raised considerably in fish processing, and such plants are continuously government inspected. Developing countries planning to export frozen fish must conform to the new requirements for quality and sanitation.

Protein in the diet could be enhanced in many developing countries by increasing the manufacture of cheeses. In some instances, milk for the production of gourmet-quality cheese for export could be obtained from sheep if milking were organized. Types of cheese requiring little or no refrigeration can be produced from cow's milk for the local market. By-product whey from cheesemaking could be dehydrated and added to animal feeds or as an ingredient in processed foods. The high-protein cake remaining from vegetable-oil extraction in developing countries can be used in animal feeds or processed to produce high-protein flour or protein isolate.

Carbohydrates

Carbohydrate raw materials are abundant in most developing countries. Advanced processing methods are needed to industrialize the processing of starchy products. Rice is the most important crop and the biggest supplier of nutritional energy in developing countries. Thousands of small rice-processing plants are being built, but they do not fit into the much needed agro-industry concept. A whole new marketing or utilization approach is needed. For example, many of the small mills might be converted into collecting and cleaning stations which would send the rice to a big, efficient central plant capable of processing up to 150,000 tons per year. The big plant would be the distributing or marketing centre.

With such an arrangement, new processes might be adopted to utilize all the nutrients in the rice more effectively. A solvent-extraction-milling process in commercial operation extracts high-grade oil from the bran and outer layers of grain for use as a food ingredient. This process yields a high-protein bran and reduces the amount of powder and broken rice grains. Still in an experimental stage is a process for deep-milling rice grains to remove the high-protein outer layers by abrasion, producing a high-protein rice flour. The remaining part of the grain can be used advantageously by brewers who want starch, not protein.

By parboiling, soluble vitamins and minerals can be transferred from the bran on rice into the grain itself so that they are largely retained during milling. In parboiling, rough rice is steeped in warm or hot water, then steamed and dried to proper moisture content for milling. Rice processed in this way has better cooking qualities for use in canned foods, in soups and in frozen foods. The added processing cost is believed to be offset by reduced breakage of the grain in milling.

The broken grains are used to make rice flour and rice starch. Rice flour and the fine rice particles removed in polishing can be used as ingredients in pastry, puddings, ice cream and confections. Rice flour lacks the gluten required for bread baking. Rice grains can be puffed to make breakfast cereals, and the puffed grains sugar-coated to make a confection. Pre-cooked rice that can be quickly finish-cooked for serving is a successful convenience food.

More effective utilization, through processing, of manioc (cassava) root represents a challenge and an opportunity in tropical countries. The year-around yield of cassava per unit area is two to four times that of wheat in terms of starch produced. The starchy roots spoil in a matter of hours after harvesting under tropical conditions. This spoilage should be prevented.

Tapioca flour and starch are made from cassava root. The flour alone does not make suitable bread, but if enriched, it can be mixed with other flour. Quantities of dry cassava chips are exported for use in animal feed. Industrial production of native cassava dishes such as gari and couscous (from wheat flour) is needed for home consumption. A woman may work all day to produce enough gari, a dried and roasted product made from cassava root, to feed her family for a day. Such wasteful expenditure of time could be eliminated by low-cost commercial processing. Perhaps a cooking-extrusion process that would gelatinize the starch, form it into desirable shapes, and feed it into toasting ovens would help to solve the problem.

Small cereal grains grown in the tropics, e.g. sorghum and millet, should also be used industrially. Perhaps the relatively new impact-in-air milling or attrition milling could be applied, coupled with air classification for precise separation into different fractions. Milo is being popped experimentally by heat to make it more suitable for animal feed, and this might be done also for millet. Research is needed to develop bread made with a blend of wheat flour and millet flour, with the object of reducing imports of wheat into some of the developing countries.

There is a trend in bread baking towards the use of the relatively new and efficient continuous-dough process. After continuous-batch pre-fermentation, liquid and dry ingredients are metred continuously into a dough pre-mixer, which discharges the dough into a mixer-developer. The dough is then extruded from the developer, loaf-size pieces cut off and dropped into baking pans on a conveyor below. The texture of such bread is fine and uniform, the product is soft, and the moisture content is high. The taste is generally more bland than that of bread produced by the conventional process. The continuous process permits considerable savings in floor space, labour and capital investment.

Brewing has undergone many changes. A few breweries in Europe have installed continuous fermentation and continuous hop extraction. Capital investment and size of plant are reduced, and automatic control is enhanced by this process. Up to now, capacities have been less than those of the bigger, conventional breweries. Another advance in brewing is bulk pasteurization of beer in continuous heat exchangers prior to aseptic bottling. This process eliminates the big and costly in-bottle pasteurizers previously employed. Some brewers have installed micropore filters that remove organisms that would spoil the beer to ensure a satisfactory shelf-life after bottling.

Cooking-extrusion is a process coming into increased use for making cereal snacks. This process gelatinizes the starch and extrudes it for further processing. Upon extrusion, the product can be cut to various lengths and forms and conveyed continuously through drying and spray-coating operations. Other ingredients can be mixed with the cereal base; a wide range of formulations is possible.

Newer processes successfully applied to tropical foods merit special attention in developing countries. In Central America, bananas are ripened in air-conditioned rooms, peeled, comminuted into *purée*, sterilized and cooled in a continuous heat-exchange system. The *purée* is then filled aseptically into No. 10 cans or 55-gallon drums for export to food processors as an ingredient. Canned banana slices are also exported. Citrus fruits of high quality are exported fresh from developing areas. This requires installation of modern washing, sorting, degreening, waxing and packaging equipment. Fruit that is not of top quality is used to produce juice and pectin. Marmalade can be made from oranges, jelly from fruits such as guava, and novel and tasty blends of juices from various tropical fruits. Tropical fruit juices can also be concentrated by evaporation and canned or frozen.

Oils and fats

Several vegetable oils of commercial importance are produced in tropical developing countries, e.g. oils from coconuts, babassu nuts, palms and palm kernels, cottonseed, safflower seed, groundnuts and olives. The integrated agro-industrial production of refined vegetable oils for domestic and foreign markets offers great opportunities. Modern vegetable-oil refining processes are efficient, continuous and automated. The crude oils can be deacidified, degummed, deodorized, decolourized, then hydrogenated to solidify them. Soap manufacture can be integrated with oil refining, since soap stock is a by-product of the alkali-refining of fats. The manufacture of salad oils, salad dressings, mayonnaise and margarine could also be integrated. Rice-bran oil could be a significant by-product of industrialized rice processing.

Polyunsaturated fats have become popular in industrialized countries because of the belief that saturated fats contribute to heart disease. Developing countries might well consider increased production and export of unsaturated oils. Safflower-seed oil is one of the least saturated, and an industry based on its production could be established in many developing countries. The oil can be sold to manufacturers of margarine, mayonnaise, salad oils, salad dressing and ice cream. Maize production is increasing in some developing areas, and the oil pressed from the germ of the maize kernel lends itself to industrial development. This oil is highly unsaturated and is used widely as a cooking and salad oil and as an ingredient in margarine. Wheat is also being grown more widely, and germ oil can be produced from the grain. The output and consumption of olive oil, which is one of the finest and most popular of vegetable oils, can be increased by the use of agro-industrial methods that improve yield and quality and reduce the cost.

Fish oil for use in foods, pharmaceuticals and industrial chemical products can be a valuable by-product of fish meal and of fish-protein concentrate plants which have been built to increase the production of protein. Oil can also be obtained from fish trimmings available from canneries and frozen fish plants.

Animal fat can now be rendered continuously. The process involves comminution of the fat, heating in continuous flow in a tubular heat exchanger, and centrifuging to separate the now liquid fat from the fibrous cellular material. This is a highly efficient, sanitary operation that produces a mild-flavoured fat and protects quality.

The fat content of milk from cows and from buffalo, which is unusually high in many tropical countries, can be combined with reconstituted powdered milk to make a good consumer product. If this combination of milks could be produced on a large industrial scale, the diet could be improved in these countries.

For efficient production of butter, continuous processes are replacing the conventional batch-churning method. One of the continuous methods involves the accelerated churning of cream of normal composition. Another continuous buttermaking process uses reseparated high-fat cream.

Chapter

THE FOOD FACTORY

Buildings

Food processing and packaging must be carried on in sanitary building that provide protection from the weather and keep out dust, insects an rodents. The floors and the walls of the processing rooms must be as fre as possible from pores and cracks where micro-organisms can collect an grow, and must be made of materials that can easily be washed down t keep the plant clean. Floors must be well drained, too. A dense type c concrete floor is adequate and is reasonably economical, but ideally i should be epoxy-coated to seal the pores. Walls of concrete or concret block coated with epoxy are satisfactory. Ceramic tile walls and chemica resistant brick floors are excellent but are more expensive. Special floo formulations can also be obtained.

The building itself can be of brick, stone, or concrete constructio with steel framing. Or it can be built of panels of aluminium, galvanize steel, plastic, or plastic-coated steel, whichever is cheaper at the plar site. Brick or stone construction requires the most labour. Concrete wa panels can be cast on site and raised into place for efficient constructio

Pre-engineered factory and office buildings and warehouses are fa gaining acceptance. They are put together from pre-designed and partiall fabricated metal framework and plain or insulated panels and may b erected relatively quickly and inexpensively. Their architecture can b attractive, too. A banana *purée* plant in Central America, for instanc is of this construction. Pre-engineered glass-lined steel storage silos wit built-in discharge conveyors are also available along with plastic va and tanks for corrosive liquids.

Water requirements

Potable water is needed in large quantities in most food-processir operations, sometimes as an ingredient in the product (e.g. soft drinl and beer), sometimes for fluming and washing the raw materials (e.

fruits and vegetables), and almost always for cleaning the plant and equipment. Possibilities of safely reusing water should be studied, both to conserve the water and to reduce the amount of waste to be handled. Water management is an important function in the operation of a food factory, especially in countries with long dry seasons.

In locating a plant in a developing country, special attention must be given to securing an adequate and dependable supply of water and to such treatment of it as may be necessary to make it clean and bacteriologically safe and to alter the mineral content to suit the use. Boiler feedwater is usually softened to avoid scale formation on the boiler tube walls.

Waste disposal

Not all countries and cities have regulations against stream pollution from the wastes of food-processing plants and other industries. Those that have not yet enacted such restrictions will no doubt do so before industrialization progresses very far. In general, waste near the plant site cannot be tolerated because of the annoying odour and health risks and because waste accumulation creates an unsanitary situation. The feasibility of disposing of process waste in a stream or in a municipal waste system should be investigated before a plant site is selected. If municipal facilities are not available, the possibility of disposing of waste by conventional treatment methods should be examined, e.g. screening out solids and then running the liquid through an aeration system or into lagoons or spray irrigation systems. Solids should be disposed of as animal feed, fertilizer, or other by-products. Dry waste can be disposed of by incineration. In residential and municipal areas pollution of the air in the neighbourhood of a food factory by processing odours, either pleasant or foul, must be avoided. Scrubbing or incinerating the air may be necessary before it is discharged to the outside from the processing rooms. Facilities for waste disposal and by-product recovery should be an integral part of the design of a new food factory. By-products can contribute profit. In pineapple canning, for example, "added-value" sweetener is recovered from plant effluent by ion exchange.

Maintenance

Adequate maintenance facilities are essential for efficient operation of processes in developing countries. Each plant should be equipped with a small metalworking shop for mechanical repairs and the fabrication of simple equipment and an electrical-electronic shop to keep motors, ot electrical equipment and instruments in repair. A versatile assortm of machine, masonry and carpentry tools and of gas metal-cutting welding torches should be available. Wet conditions in many f factories, or the careless use of water hoses in plant cleanup, can sho the life of electrical equipment and cause breakdowns. Motors electrical gear designed especially for such conditions (and also for tropics) should be specified when the plant is being equipped.

It is much easier to stock parts if similar types and makes machines are used. This is particularly important when the plant is from a source of parts. Management should ensure that the parts dep ment of the maintenance shop is well stocked and should use a systema preventive maintenance system to avoid breakdowns.

UTILITIES

Food plants do not normally require large quantities of elect energy; the amounts needed are purchased from public utilitie generated by the plant's own diesel-electric or turbo-electric unit electricity is purchased, a diesel-electric stand-by generator is neces as a precaution against power failure. When a diesel engine is ope regularly, waste heat should be recovered for use in processing from cooling system of the engine and from the exhaust. Some food proce generate high-pressure steam to drive a turbo-generator that pro electricity for the plant and perhaps also for sale to a public utility other local customers. Steam for processing is bled from the turbine charge at low pressure. This is an economical arrangement that m evaluation in tropical processing plants. "Package" steam generato boilers, complete with controls, are recommended.

An efficient and flexible system for distributing electricity tributes more than the extra cost of its installation by preventing v drops that impair machine performance and resistance wattage that boost the power bill. In process and packaging rooms an ove electrical bus duct with many plug-in boxes permits easy connexi new or rearranged equipment. A well planned lighting system inc the productivity of the workers and reduces accidents. Special illu tion should be provided over inspection belts and wherever precise performance is required. Outdoor floodlighting of factory premi advisable as a plant security measure, and stand-by battery-powered inside lights are needed for safety when the electricity supply fails. An in-plant communications system, either wired or radio, is necessary for proper factory control, and an electronic security system is recommended in order to keep out or detect unauthorized personnel.

Refrigeration systems are installed in many types of food factories to provide refrigerated storage of raw materials, ingredients and finished products. Refrigeration may also be needed for cooling or freezing operations in processing or for air-conditioning process rooms and offices. Air compressors are usually installed to provide air for pneumatic process control systems, air-operated tools and actuators, air-cleaning hoses, air agitation and other uses.

Facilities for personnel

Provision must be made for employee comfort and personal sanitation. The plant needs toilets, locker rooms and wash rooms, as well as wash basins where production workers can disinfect their hands in chlorinated water before and after work. A comfortable place should be provided for employees to eat lunches brought from home, and a cafeteria or food-vending machines may be advisable. A first-aid station is essential, and a nurse on the premises is recommended. A physician should be available on short notice to handle anyone injured in accidents and to check the health of new workers or workers returning to the plant after sickness. Some diseases, such as typhoid, can be transmitted by food-borne bacteria or viruses, and carriers of such diseases cannot be allowed to work in food plants.

It is a wise policy to provide employees with an air-conditioned room or shaded patio for eating and relaxation. Some plants even make recreational facilities available; this is especially important when workers need after-hours amusement to keep them satisfied. Even housing for managers and workers can be required. Schools for employees' children and hospital facilities for families are frequently found in remote areas. Sometimes company-operated stores are the only place where people at the plant can purchase personal supplies. The more remote the location the more complete the facilities that must be provided in a practical, over-all factory setup.

Other facilities and equipment

Fire-fighting facilities must be installed in every factory. These range from built-in, automatic sprinkler systems to fire extinguishers placed throughout the plant. Precautions should be taken against an explosion of organic dust, such as flour or starch, mixed with air. Explosion-proof electrical equipment and devices for preventing the buildup of static electricity on conveyor belts may be needed. Explosion-prone processing systems can be equipped with suppressors that instantly extinguish a flame before it can flash into an explosion.

In some types of food-processing plants, air conditioning may be needed for technical reasons, such as to keep chocolate firm in tropical climates or to keep meat cold and firm in cutting rooms. In others, as in a bakery where much heat is generated, or in a cannery where considerable vapour is produced, special high-capacity ventilating systems may be necessary. These usually require exhaust fans on the roofs. Coating the roof with aluminium or white paint helps to keep a plant cool. A spray or pool of water on the roof is also effective. Tinted or blue-painted window glass helps to keep out heat from the sun.

Mechanical equipment for handling materials is essential for plant efficiency. Battery, gasoline, or low-pressure, gas-powered industrial lift trucks and pallets are basic equipment for general purpose handling of materials and products. Power conveyors are installed for continuous handling over fixed routes. A great variety of conveyors is available to suit every situation, including mechanical and pneumatic conveyors. Pneumatic conveyors are highly efficient in handling dry materials in large volume. Automatic controls are needed to assure process efficiency and product quality. For a plant laboratory controlling quality, basic analytical instruments are essential. Motor trucks to haul raw materials to the factory and finished products or wastes away are a normal adjunct of food-processing establishments.

FOOD-PROCESSING INVESTMENT FACTORS

To produce processed foods of a quality and at a price that will compete in world markets requires a modern factory, no matter where it is located. Key investment factors and economic profiles for several food plants are given below.

INVESTMENT FACTORS FOR UNITED STATES
(average for 1967)

Return on invested capital	11.1%
Return on sales	2.4%
Sales per employee	$42,696
Assets per employee	$20,508

These statistics indicate to management and to investors that food processing is a highly competitive industry that operates with a small profit per unit of sale and therefore depends on high volume to make a satisfactory income. The low competitive margin requires efficient processing and packaging to ensure profit; these in turn call for high capital investment per worker. Such investment is evidence of the technical sophistication of modern food manufacturing.

It is clear that large-scale food processing establishments are in a better position to make a satisfactory return on investment than smaller plants that are less well equipped. Labour-intensive food-processing operations are decidedly more expensive than highly mechanized operations. In labour-intensive operations, product quality and sanitation suffer. Workers make mistakes that machines avoid. Workers can also be prime sources of contamination of food products. The labour-intensive plant requires more floor space and more supervisors and generates more labour demands on management than does a mechanized plant.

Investment in a modern food-processing factory in an industrialized country ranges from about $1 million for a medium-size, mechanized bakery to $20 million for a big sugar refinery and $45 million for a huge

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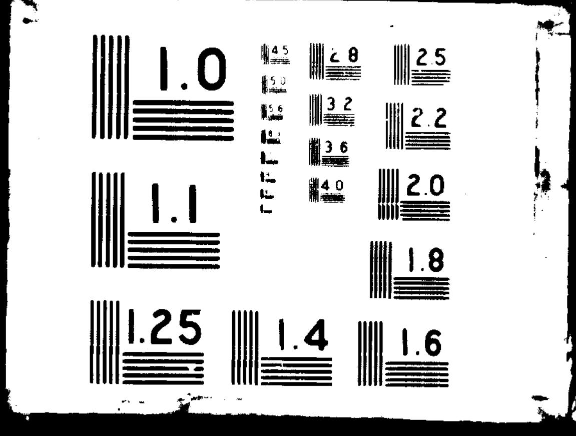

brewery. High-capacity, continuous cooker-coolers and hydrostatic cooker-coolers used in canning cost $100,000 and more. For example, a Freon immersion-spray quick-freezer with a capacity of 3,000 pounds per hour sells for about $90,000, and approximately that much more is required for its complete installation with auxiliary equipment. A small machine to package milk in one-quart polyethylene bags costs about $21,000.

It can be seen from these examples and others that follow that food-processing equipment is expensive. Leasing of machinery is a growing practice in industrialized countries. By leasing major machines, a plant can be put into operation with a relatively low fixed capital investment. Whether equipment can be leased in developing countries must be investigated in each instance. Leasing should perhaps be covered by government assurances limiting losses in order to reduce capital investment and speed progress.

An example of the costs of processing facilities

Many different types of food-processing equipment are required for vacuum-drying whole milk. Prices of typical equipment for American factories in the fourth quarter of 1968 are listed below.

Item	*Number of items*	*Price f.o.b. for all items*
		(dollars)
Cooler, plate type, 80 gal/h, stainless steel	3	4,800
Milk tanks, jacketed for cooling, 20,000 gal	2	33,000
Sanitary feed-pump, positive, variable speed, 900—1,100 gal/h	1	1,350
Plate heat exchanger to pasteurize and cool milk	1	5,400
Holding coil, sanitary stainless steel tubing (30 sec, 140° F)	1	1,120
Homogenizer, 3,000 psig, 900—1,100 gal/h, single-stage	1	8,800
Holding coil ($16^1/_2$ sec, 162° F, 1,050 gal/h)	1	1,040
Flow-diversion valve, sanitary (automatic, with controls)	1	1,900
Cooler, plate heat exchanger	1	2,700
Pasteurized milk storage tanks, 15,000 gal	2	28,000
Feed-pumps, positive, variable speed, 320 gal/h (incl. in evaporator price)	—	—
Pre-heater, stainless steel, 320 gal/h	3	5,400
Evaporators, thin-film, 2,000 lb of water/h	3	171,000
Product pumps, 80 gal/h, sanitary (incl. in evaporator price)	—	—
Homogenizer, 2-stage, 3,000—5,000 psig, variable speed, 80 gal/h	3	20,400

Item	*Number of items*	*Price f.o.b. for all items*
		(dollars)
Scraped-surface gas-dispersing unit, single tube	3	18,000
Feed-pump, 95 gal/h, positive, variable speed, sanitary	3	2,850
Heat exchangers, 95 gal/h, plate type	3	4,200
Dryers, continuous vacuum type, 4 × 98 ft, stainless steel belt	2	910,000
Conveying system, enclosed air-tight screw type, stainless steel	1	7,500
Hoppers, 300 ft³, air-tight, stainless steel	2	6,000
Canning line for dry milk powder in No. 10 cans, nitrogen pack	1	85,000
Air compressor, for automatic controls	1	4,500
Clean-in-place system, for milk-processing equipment	1	13,000
Refrigeration units, 15 tons each	2	20,000
	TOTAL	1,355,960

The start-up expense for a new plant of this type is estimated at $100,000. Total capital costs, including processing equipment, buildings, land and non-processing equipment, is placed at $2,283,960. With $269,000 for working capital, the grand total of capital costs comes to $2,552,960.

The output of a milk-drying plant with the above equipment would be 61,955 quart-equivalents of whole milk powder per 24-hour day (6,196 No. 10 cans). The input of raw milk would be 131,300 pounds per day five days per week.

It is estimated that 20 workers are needed for three shifts, plus a plant manager, superintendent, laboratory head and assistant, mechanic, shipping and receiving man, and a secretary-typist. Steam requirements are 10,000 lb/h; electricity 23,000 kWh/d; water 1,100,000 gal/d; waste disposal charge $20/d.

The total capital costs for the milk-drying plant are:

	Dollars
Land and site preparation	6,000
Roads and parking areas	5,000
Buildings (plant 100 × 100 ft; warehouse 2,700 ft²)	260,000
Boilers (10,000 lb/h steam at 125—150 psig)	42,000
Processing equipment (from previous table)	1,355,960
Erection of processing equipment (less dryers, evaporators)	40,000
Instrumentation	60,000
Piping and ductwork	50,000
Erection of piping and ductwork	30,000
Lighting (included in building cost)	—
Electric power—installed	75,000

	Dollars
Transporter (lift truck)	7,500
Insulation (steam lines)	2,500
Freight on equipment (less dryers, evaporators)	7,000
Office furniture and fixtures	5,000
Fire and safety equipment	3,000
Contingencies	200,000
Engineering fees	100,000
Contractor's fees	35,000
Heating (included in building cost)	-
TOTAL FIXED CAPITAL	2,283,960
WORKING CAPITAL	269,000
TOTAL CAPITAL REQUIRED	2,552,960

ECONOMIC PROFILES OF FOOD PLANTS

Economic profiles of several food-processing establishments in various countries are presented in a study carried out by UNIDO.[2] Representative profiles are reproduced in condensed form below.

Dairy plant in France

Major products: milk (sterilized and pasteurized), yogurt, fresh cream and cheese. Annual capacity of milk processing: 60 to 80 million litres; yogurt 6 to 8 million litres. One-shift operation. Established in 1964.

1. FIXED CAPITAL ASSETS (END OF 1964)

	French francs (thousands)	
Total book value before depreciation		28,441
Land	2,417	
Buildings	9,190	
Machinery and equipment	12,621	
Vehicles	3,803	
Office furniture and fixtures	410	

2. VALUE OF INVENTORY (END OF 1964) 6,880*

** About 5 per cent above normal inventory.*

3. VALUE OF ANNUAL PRODUCTION (1964) 48,883

Output at rated capacity would be 40 per cent higher with an investment of 500 thousand francs minimum to clear a bottleneck in the milk factory space.

[2] *Profiles of Manufacturing Establishments;* for full reference see annex 3 under "United Nations Industrial Development Organization".

		French francs (thousands)	
4.	INTERMEDIATE INPUTS (1964)		
	Total value of consumption		43,334
	Energy and water	715.0	
	Direct production materials	39,575.6	
	Packaging materials	622.3	
	Repairs and maintenance	468.9	
	Material inputs for auxiliary activities	1,026.1	
	Non-factor service inputs (transport, insurance etc.)	925.8	
5.	VALUE ADDED (1964)		5,549
6.	SELECTED COEFFICIENTS		
	Value of equipment per employee in direct production	62.8	
	Value added per employee	11.6	
	Annual wage per employee	11.8	

Variable input costs/gross production: 88.6%

Gross profits/gross production: 1.2%*

The level of production at break-even point is about 90 per cent of actual production in 1964.

* *4.1 per cent at full capacity.*

7. LABOUR (ONE-SHIFT, 1964 AVERAGE)

	Number of employees
Total employed	478
Direct production (annual total man-hours: 512,000)	201
Maintenance	34
Distribution, management etc.	243

Dairy plant in India

Major products: pasteurized milk, ice cream, milk powder, butter and ghee. Plant capable of processing over 50 million litres of raw milk with two shifts. Established in 1960.

1. FIXED CAPITAL ASSETS (END OF 1963)

	Indian rupees (millions)	
Total book value after depreciation		17.89
Land	2.55	
Buildings	5.22	
Machinery and tools	7.82	
Vehicles and office furniture	2.30	

Dairy plant in India *(continued)*

	Indian rupees (millions)	
Details of machinery and tools (replacement value 1964)		
Processing plant	1.33	
Bottling plant	2.96	
Butter, ghee and ice cream plant	1.45	
Boiler house	1.12	
Refrigeration	1.96	
Laboratory	0.22	
Can-working plant	0.04	
Milk-chilling plant	3.38	
Capacity of electric motors: 2,250 kW		
Total load capacity of trucks: 480 metric tons		

2. VALUE OF INVENTORY (END OF 1964) 2.47*

* *About 9 per cent above total normal inventory. Normal inventories of finished products are 2.8 per cent of annual gross production.*

3. ANNUAL PRODUCTION (1964)

	Quantity	Unit value (rupees)	
Total value of production			28.69
Whole and skim-milk powder (metric tons)	147	3,578	
Butter (metric tons)	53	6,740	
Ghee (metric tons)	59	7,400	
Pasteurized milk (thousand litres)	28,711	650	
Toned milk (thousand litres)	20,601	420	
Ice cream in cups and bars (thousands)	182	307	

Output at rated capacity: 30 per cent higher than the 1964 actual level with no additional man-hours. The under-utilization is mostly due to the insufficient supply of milk.

4. VALUE ADDED (1964)

Total		—2.42*
Wages and salaries (before income tax)	2.25	
Annual depreciation allowance	0.94	
Sales and other indirect taxes	—5.61	

* *Since this is a Government plant, prices are kept below cost; the Government subsidizes the apparent loss of 5.61 million.*

5. SELECTED COEFFICIENTS

	Rupees
Value of equipment per employee in direct production on first shift	24,900
Value added per employee	1,000
Annual wage per employee in direct production	707

6. LABOUR (1964 AVERAGE)

	Number of employees		
	First shift	Second shift	Total
Total	2,852	331	3,183
Direct production	500	331	831
Transport, technical control and supervision	2,352	—	2,352

Annual total direct production man-hours: 1st shift—1,270,000; 2nd shift—810,000.

Wheat flour mill in Yugoslavia

Capable of processing 65,000 metric tons of wheat annually on three shifts. Established in 1960.

1. FIXED CAPITAL ASSETS (END OF 1963)

		Yugoslav dinars (millions)	
Total 1963 replacement value			1,670
Buildings and land improvements		920	
Machinery (domestic makes)		750	

Capacity of electric motors: 1,151 kW.

Mechanization is rated as 65 per cent and automation as 40 per cent of most advanced world standards.

2. ANNUAL PRODUCTION (1963)

	Quantity (metric tons)		
Total actual revenue output			3,244
White wheat flour	12,164	937	
Bread wheat flour	28,107	1,771	
Bran	8,981	207	
Grits	190	7	
Seeds for animal feed	1,220	22	
Revenues from milling services		300	

3. INTERMEDIATE INPUTS (1963)

	Quantity		
Total value of actual consumption			2,736
Energy inputs:			
Electricity (MWh)	2,536	30	
Lignite (metric tons)	27	2	
Liquid fuel		6	
Major production materials:			
Wheat (metric tons)	51,030	2,398	
Other materials		156	
Repairs and maintenance		19	
Other inputs		125	

4. VALUE ADDED (1963)

Total (except turnover tax)		494
Wages of factory workers	144	
Salaries of non-factory workers	37	
Depreciation	45	
Interest paid	146	
Other accumulation	122	
(Turnover tax)	(14)	

5. SELECTED COEFFICIENTS

Value of equipment per factory worker on first shift	11.7
Value added per employee	3.1
Annual wage per factory worker	1.2

Variable input costs/gross production: 84.7 %

Gross accumulation/gross production: 8.3 %

The level of production at break-even point is about 46 per cent of actual production in 1963.

Wheat flour mill in Yugoslavia *(continued)*

6. LABOUR (1963)

		Number of employees
Total employed		162
Factory workers (man-hours: 362,000)	124	
Non-factory workers (man-hours: 73,000)	38	
Education of workers		
University	3	
Technical high school	8	
Secondary school	18	
Primary school	133	

Fruit and vegetable canning plant in Israel

Capacity about 20,000 metric tons annually, worked on partial three shifts. Established in 1937.

1. FIXED CAPITAL ASSETS (END OF 1964)

		Israeli pounds (thousands)	
Total book value before depreciation			1,912
Land (17,000 m²)		(rented)	
Buildings (floor space 7,000 m²)		496	
Other construction works		133	
Machinery and equipment		1,186	
Tools, vehicles, furniture		97	
Details of machinery and equipment			
Squeezing machines (8)	(rented)		
Auxiliary equipment	200		
Juice extractor (1) and centrifuges (3)	150		
Pasteurizer (1) and vacuum machines (3)	120		
Barrel-filling line	15		
Pasteurization equipment	15		
Other	566		

2. VALUE OF INVENTORY (END OF 1964) 1,908*

* *Normal inventories of finished products are 16.6 per cent of annual gross production.*

3. ANNUAL PRODUCTION

	Quantity (metric tons)		
Total value of production			4,517
Natural orange juice	2,000	1,200	
Squash	500	450	
Concentrated juice	400	440	
Pasteurized juice	3,000	600	
Canned cucumbers	200	160	
Canned tomatoes	1,300	390	
Other foods		1,277	

Output at rated capacity: about 100 per cent higher than the 1964 actual production level without addition to man-hours. The under-utilization is due to insufficient demand for the products and insufficient supply of raw and intermediate materials.

		Israeli pounds (thousands)	
4.	INTERMEDIATE INPUTS (1964)		
	Total value of consumption		2,912
	Energy and water	498	
	Direct production materials	1,267	
	Packaging materials	1,026	
	Maintenance	79	
	Materials for auxiliary activities	12	
	Non-factor service inputs	30	
5.	VALUE ADDED (1964)		
	Total		1,605
	Wages and salaries (before income tax):		
	Employees in direct production	430	
	Other employees	222	
	Other expenditures for employees	401	
	Annual depreciation allowance	141	
	Rental paid (and other)	100	
	Other gross business income (before income tax)	311	
6.	SELECTED COEFFICIENTS		
	Value of equipment per employee in direct production on first shift	19.8	
	Value added per employee	10.0	
	Annual wage per production employee	4.3	

Variable input costs/gross production: 61.8%
Gross profit/gross production: 6.9%*

The level of production at break-even point is about 82 per cent of actual production in 1964.

* *22.5 per cent at full capacity.*

7. LABOUR (1964 AVERAGE)

	First shift	*Second shift*	*Third shift*	*Total*
	Number of employees			
Total	120	20	20	160
Direct production	60	20	20	100
Auxiliary activities	—	—	—	60

Annual total direct production man-hours: 132,000.

Education of workers

University or higher	4
Senior high school	48
Others	108

Fish- and fruit-canning plant in Japan

Annual capacity of 220,000 cases of canned fish and canned fruit (containing about 1,000 metric tons of tuna and peaches) on one-shift operation. Established in 1959.

Fish- and fruit-canning plant in Japan *(continued)*

	Quantity	Japanese yen (millions)		
1. FIXED CAPITAL ASSETS (END OF 1964)				
Total book value before depreciation				44.5
Land (2,805 m^2)			17.0	
Buildings			23.2	
Machinery and equipment			3.5	
Vehicles			0.8	
Details of machinery and equipment				
Fish cutters		0.30		
Belt conveyors		0.15		
Canning plant machines		2.00		
Washers		0.30		
Heat sterilizing boilers		0.20		
Thrashing machines		0.20		
Packing machines		0.10		
Boilers		0.25		
Condition of belt conveyors: not as good as new, but efficient for current production.				
Condition of other machinery and equipment: excellent.				
Average age of equipment: 5 years.				
2. VALUE OF INVENTORY (END OF 1964)				25.8*
* *About 6 per cent less than normal inventory.*				
3. ANNUAL PRODUCTION (1964)				
Total value of production				248.7
Canned fish (cases)	176,790		224.5	
Canned fruit (cases)	9,830		24.2	
Output at rated capacity: 20 per cent higher than the 1964 actual production level with only a slight increase in manual labour.				
4. INTERMEDIATE INPUTS (1964)				
Total value of consumption				198.0
Energy and water			1.2	
Direct production materials			136.2	
Packaging materials			55.0	
Maintenance			0.9	
Material for auxiliary activities			2.7	
Non-factor service inputs			2.0	
5. VALUE ADDED (1964)				
Total				50.7
Wages and salaries (before income tax):				
Employees in direct production			39.3	
Other employees			1.1	
Other expenditures for employees			4.8	
Annual depreciation allowance			3.1	
Sales and other indirect taxes			0.1	
Other gross business income (before income tax)			2.3	

6. Selected coefficients

	Japanese yen (thousands)
Value of equipment per employee in direct production on first shift	38.5
Value added per employee	517
Annual wage per employee in direct production	414

Variable input costs/gross production: 80.5%

Gross profit/gross production: 0.95%*

The level of production at break-even point is about 95 per cent of actual production in 1964.

* *4.1 per cent at full capacity.*

7. Labour (1964 average)

	Number of employees	
Total employed		**98**
Direct production (annual total man-hours: 218,900)	**95**	
Auxiliary activities	**3**	
Education of workers		
University or higher	—	
Senior high school	**1**	
Others	**97**	

Chapter 7

THE INTERNATIONAL SYMPOSIUM ON INDUSTRIAL DEVELOPMENT: ISSUES, DISCUSSION AND RECOMMENDATIONS

The issues presented to the Symposium, a review of the discussion, and the recommendations approved are presented in this chapter.

THE ISSUES[3]

Food production and processing are among the most important industries to be established in developing countries where many of the food sources are not utilized, intensive food production for the market is lacking, and production and preparation of food are still a family affair. The growth of the food industry in developing countries will reduce raw material losses, improve public health and encourage agricultural production.

Food processing in modern factories also creates the possibility for a developing country to export food to developed countries. The food industry also stimulates allied industries, creating a steady demand for packaging materials, tinplate, glass containers, animal feeds, fertilizers, pesticides, processing equipment etc.

In developing countries, there is generally an atomized production of raw materials by small farmers with surpluses of vegetables, meat, milk and other commodities amounting to no more than 10 per cent of their whole production. The processing equipment facilities are often operated under poor sanitary conditions, producing a large assortment of unstandardized food products with high production costs. The industry is often dependent on imports for packaging and other materials. A market for foods processed domestically is practically non-existent in developing countries. There is competition from imported processed foods which are of a better quality and, in spite of import taxes, often cheaper than the high-cost domestic product. Lack of public utilities—water, electricity, fuel, transportation facilities—requires the food process factory to invest

[3] From Issues for Discussion: Food Processing Industry, 1967 (ID/CONF. 1/A. 9) (mimeo.).

in its own utilities, which raises costs. The distribution of the processed foods involves a more complex task than just its transportation. Investments needed to realize a cold chain for transport, storage, and retail distribution of chilled, frozen, fresh and other processed food products are sometimes more than five to ten times the amount needed to establish a food-processing facility itself.

The present world production and processing facilities are inadequate to provide sufficient food for large sections of the world's expanding population, and the situation is deteriorating.

Planning and programming of food development

In every developing country, a comprehensive food-processing programme on a long-range basis should be outlined which will integrate the efforts of government food-processing experts, education centres, engineering organizations and other related activities. The Asian Conference on Industrialization recommended that an economic and technological survey of food processing industries be undertaken by the ECAFE secretariat in co-operation with other United Nations agencies to supplement the food products and nutritional surveys undertaken by FAO, and proposed that this issue be discussed at the International Symposium. Such a long-range programme should include projections of demand for the domestic and export markets, of the investment capital needed, of the required processing equipment, of the changes needed in agriculture, and requirements of process engineering, energy, water, and other facilities, the approximate location of plants and the means of transport. A special body should be established to initiate and implement this long-range programme, to supervise the bids and offers, to organize the supervision of quality and standards and assist in production, distribution and export of the products.

Food marketing

An evaluation of domestic and foreign markets must be undertaken before a plant is built. The introduction of new processed forms of food is sometimes difficult in developing countries. International organizations could provide the developing countries with marketing specialists to advise in planning and implementing marketing programmes simultaneously with their technological programmes.

Exchange of technology and experience

Special attention should be given to the possibilities of regional and bilateral co-operation in the food-processing industry in the form of mutual technical assistance, interchange of experience, research, trainees, operating

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personnel and marketing specialists. It would be a proper function for international bodies to sponsor or assist the establishment of regional research institutes or to assist the existing institutes to expand their activities in research, engineering and marketing.

Industrialization of the production of raw materials

Modern processing facilities should be planned in such a way that they will not be dependent on the production of thousands of individual farmers. Industrial production of the raw material should be planned. The quantity, quality, and scheduling of raw material production and its supply to large, efficient food-processing plants can be carried out more satisfactorily by agro-industrial production than by the traditional methods of agriculture. Agro-industrialization, therefore, is an important objective, and international assistance in developing such agro-industrial complexes in developing countries should be organized and supplied

Protein production

There is a serious need for substantial increases in the protein diet of the developing countries. About 60 per cent of world population has a daily consumption of less than 15 grams of protein. Protein production for human consumption from vegetable sources cannot be carried out without large industrial facilities. The exploitation of new, non-conventional sources of protein for human consumption should be undertaken in highly mechanized, automatized units. Developing countries should be given international assistance to help increase the protein level in the domestic diet by (*i*) growing and processing protein-rich crops; (*ii*) producing more animal proteins by using protein-enriched feedstuffs; (*iii*) the use of bio-synthesis; and (*iv*) producing synthetic amino acids for enrichment of poor grain and other low-protein foods. There is need for international measures to pool and transfer knowledge of existing processes and experience in protein production for the benefit of the developing countries.

Processing carbohydrate foods

In almost all developing countries, carbohydrate foods are staple foods, the cheapest source of energy and sometimes the exclusive diet of the poor. At present, the processing of the raw materials (e.g. rice, millet, guinea corn, arrowroot, tapioca, manioc, sweet potatoes, cassava, yams) is carried out in the household. The grains and roots are normally ground or extracted only a few hours before consumption. If not consumed promptly, this food is spoiled. Many problems are involved in the industrialization of processing these important foods in developing countries. New unit operations should be investigated before such industrialization is undertaken.

Processing fats and oils

The export of processed palm kernels, cocoa beans, groundnuts, sesame and castor seeds and many other oil bearing materials is a source of foreign exchange to developing countries. The by-product of this production is protein-rich pressed cake, which is important for animal husbandry. International assistance is needed for the development of an all-round standardized unit process for extracting and refining vegetable oil from most of the oil-bearing tropical materials.

Standardization

There is need for the establishment of international standards of quality, packaging and labelling of processed foods. Differing national standards constitute an important obstacle to developing countries in their efforts to expand their exports of processed foods to advanced countries. As importers of manufacturing equipment, on the other hand, they would benefit from international standardization. The goal of equipment standardization should be to provide for multi-purpose operations. It should also be possible to standardize bids and offers for food processing equipment, entire food-processing lines, and complete "turn-key" factories with pertinent specifications. The United Nations, its specialized agencies, the International Organization for Standardization (ISO) and associations of branches of the food industry may consider evolving a special standards programme embracing the products, equipment, processing methods and contract procedures in the food industry.

THE DISCUSSION[4]

The importance of establishing or improving the food-processing industry in developing countries was generally accepted. It was stressed in particular that this industry might increase the export earnings of developing countries and reduce the need for imports of processed foods. At the same time, an expansion of markets through food processing would

[4] From *Report of the International Symposium on Industrial Development, Athens 1967* (ID/11) (United Nations publication, Sales No.: 69.II.B.7).

lead to the growth of agricultural production. In addition, food processing can lead to nutritional benefits for the local population and serve as a basis for further industrial growth. It was accepted, however, that there was no magic formula for industrialization of food processing. While each region, perhaps each country, can learn from the experience of others, it would nevertheless have to face its own particular industrialization problems.

Stress was laid on the need for a sufficient and continuous supply of good-quality, reasonably priced raw materials produced specifically for processing. In many developing countries a large part of the crop is consumed by farmers themselves, so that insufficient surplus remains for a processing industry. In many regions there were considerable difficulties in transporting the raw material from the farm to the place of processing.

The particular problems of establishing food-processing plants were discussed, including the lack of finance, trained manpower, technical know-how and research facilities. Solution to some of these problems should be sought on a regional basis. The particular products should be adjusted to the needs of the markets: where processing was for local markets, the prime need was for a low-cost product that would compete with the local hand-produced foods and be cheap enough for purchase by local customers. Where, however, the product was to be sold in export markets, it must often meet the requirement of international standards, and this might involve greater costs.

The dependence of food processing on availability of raw materials and on distribution and marketing facilities was generally recognized. Many delegates produced examples to show how the organizational difficulties of ensuring an efficient flow from farm to housewife had been overcome. These examples included the working of private companies; of producers' co-operatives for the collection, processing and distribution of the food products; and of agro-industrial complexes. It was stressed that each country must choose the form of organization that would best suit its economic, social and political requirements.

The particular type of processing operation would depend upon the conditions in the country or region. In this connexion, comment was made on the great problem of applying and adapting existing processing methods to suit local conditions. In many cases, waste resulted from inefficient drying and storage methods, which could be greatly improved by simple means. The need for research into new processing methods was stressed. Preference was expressed for agricultural processing industries which would use the respective raw materials to the fullest possible extent, including the production of new and improved products from by-products and offal.

In view of the chronic shortage of protein in many developing countries, interest was expressed in recent developments in production of proteins and protein-enriched foods. It was suggested that the order of priorities should be: improvement in the production, processing and marketing of existing protein foods; the development of new protein foods; and the synthesis of protein by microbiological means.

Many examples were given of successful industrialization of food processing. Examples were given of food products which certain developing countries are now successfully producing, either for local consumption or export markets, or both. Successful projects established in a number of developing countries were described; the success of these and other projects, particularly where foreign capital was involved, was considered to depend to a large extent on maximum participation of local manpower and resources and a fair return to all, on the basis of a good co-operative relationship between local and external interests.

Many participants cited examples of the difficulties encountered in establishing food-processing industries in developing countries, and many references were made to the assistance UNIDO and other international organizations could give to help solve these problems. The fullest co-operation should be ensured with international organizations already working on food processing, particularly FAO, in order to avoid duplication and overlapping.

In view of the importance of the food-processing industry to the economies of developing countries, many delegates affirmed the willingness of their countries to support the efforts of the developing countries to establish or expand such industries by contributing information, know-how, technical assistance, capital and financial aid, either directly or through UNIDO and other international agencies. The point was made that some developing countries should be encouraged to contribute more support than they have in the past.

Achievements and requirements cited

Agro-industrial complexes in Yugoslavia

The experience of Yugoslavia was cited as indicating that agro-industrial complexes may give good results in the development of agriculture and also play a role in the interrelationship of industry and agriculture. The very favourable advance in Yugoslav agriculture in recent years was seen as a result in large part to the establishment of big agro-industrial complexes.

A representative of FAO expressed the view that the promotion of integrated agro-allied industries, supported by producer co-operatives, could be achieved rather quickly and successfully. An example was cited of an Eastern Mediterranean country in which a group of vegetable and fruit growers concentrated on the establishment of a tomato paste plant. Since outside skills and capital were needed, a three-party arrangement was made involving a Swiss industrial firm, the Government and a co-operative of farmers. In less than six months, the plant was nearly completed. Such a combination of foreign capital, a farmer co-operative and the Government could in many cases give useful results, and the international organizations could also assist.

Industrializing maize in Pakistan

The experience of an American firm in a developing country was sketched. Less than five years ago, the company studied the possibility of industrializing maize in Pakistan. It investigated the existing market for grain products, the industrial growth of the country, its projected potential market, and the production, field yield, varieties and prices of maize. The firm then started a manufacturing operation in Pakistan, which was an outstanding success, so that the company then planned to increase the capacity of the plant. The markets for its food products, its industrial products, and feedstuffs rapidly expanded.

A small company was formed to develop maize hybrid seeds in order to improve the field yield, the company providing the farmers with precise advanced technical information on growing, harvesting, drying and storage of maize. Apart from the sound investment of the foreign firm, this undertaking improved the standard of living in a modest way for a reasonable number of people in Pakistan, contributed importantly to the advancement and improvement of agricultural practices in maize growing, and helped to upgrade the food products industry in Pakistan. The business was operated almost entirely by Pakistan nationals on the basis of co-operation in a common cause with mutual rewards.

Overseas companies must investigate many aspects of such a venture before making an investment in food manufacture in a developing country. The objective and the planning must be sound economically and must ensure added reward to each contributor, as each contributor will add value to the product in the various stages from the growing field to the end consumer.

Unless all elements—the supply of agricultural raw materials, the conversion of raw materials into acceptable food products, packaging, distribution, and marketing—can be efficiently linked into a dynamic chain or system, the objectives will not be realized. Failures often result from the non-existence or deterioration of one or more of the links in the chain.

The plan of integration must be prepared by the country itself:

Channels must be cleared to protect investment from abroad;

Assurance must be given that earnings may be remitted at levels in keeping with standard and equitable international criteria; free of excessive taxation;

Importation of plant equipment and food-packaging materials must be free of duty;

If food products are to move in international trade they must meet the standards of products developed in or produced in developed countries;

Transportation rates on raw materials supplied to the processing plant, and the cost of transportation of finished goods to markets, should not be excessive if moved over government-controlled pathways.

Industrializing fisheries in India

Attention was called to a project the aim of which was to rationalize Indian fisheries by the introduction of motor vessels, modern fishing equipment and methods, and development of a system of distribution of fish. The project aims included the control and the improvement of food standards and of the general standard of living in the area. The project was at first confined to two fishing villages, later expanded to include additional fishing stations. Norway presented India with three modern, ocean-going trawlers and a well-equipped oceanographic research vessel to map the fishing grounds on the southern and western coasts and to chart those waters thoroughly. The transition from coastal to oceanic fishing, the primary object of the project, was confirmed in 1967 in a new five-year agreement.

The transition to motorized fishing vessels and more modern methods progressed at an accelerated pace. In all, the project was so successful that it was taken as a model for the modernization of the Indian fisheries in general. In addition to providing more and better seafood for local consumption, the project resulted in the export of seafood at a value of about 170 million rupees per year.

The Norwegian industrialist citing this project indicated that the Norwegian agency for international development would consider requests for assistance in this field. He referred to other examples of aid, for example, a fish mill and oil plant bought by a shipowner in Norway and moved to a Latin American country where it had been in operation for several years; and a cold storage plant and distribution business established and operated by a Norwegian shipowner in a West African country.

The food and beverage industry in Cyprus

Confirming the view that greater attention must be given to the development of new products, a consultant from Cyprus reported that in his country several new high-export-value agricultural products had helped to increase agricultural exports in three years from 8,500,000 pounds to 11,255,000 pounds. Considerable expansion in the beverage industry through development of new product lines was reported. Food exports rose from 28 to 38 per cent of total exports from 1960 to 1966, while those of beverages increased from 4 to 8 per cent. It was expected that the gross output of food and beverages in 1962 would be approximately doubled by 1971.

It was suggested that the best way for a developing country to begin the development of new products was to find out what products were in demand in the world market and the possibilities of their cultivation and processing. Research had revealed, for example, that the addition of only one product would make it possible to increase the total exports of the Cyprus canning industry by about 30 per cent.

Recommendations approved[5]

That increased attention be given to the problems of establishing food-processing industries in developing countries in view of the importance of such industries to the economy, social structure, and nutritional level of these countries;

[5] From *Report of the International Symposium on Industrial Development, Athens 1967* (ID/11) (United Nations publication, Sales No.: 69.II.B.7).

That more information be systematically disseminated about food processing, including, where feasible, model projects for various food-processing industries which would show:

(*a*) The most economic equipment layout;

(*b*) For each type of equipment, its specifications, costs and supplying companies;

That developing countries be assisted in finding the right type of food-processing equipment to suit their individual market requirements;

That feasibility studies be undertaken for the establishment of various food-processing industries in several countries and regions;

That assistance be given upon request to help developing countries establish training and technical institutes for food processing;

That UNIDO, in response to requests from developing countries with the necessary marketing, industrial, agricultural and other economic conditions that favour additional processed food production through agro-industrial complexes, should provide assistance in establishing and implementing such projects in co-operation with other international organizations, in particular FAO, as appropriate.

UNIDO ACTION TO PROMOTE FOOD-PROCESSING INDUSTRIES

UNIDO's objective is to promote and accelerate the industrialization of food-processing industry in developing countries and to help make it efficient. The view of the Organization is that high standards of efficiency in this industry require modern equipment and advanced technology. Reorganization of the traditional branches of the industry, e.g. sugar-, rice- and meat-processing, is important in this connexion.

Production for export is a key aspect of UNIDO's programme, and the promotion of the food-processing industry has the aim of producing foods that can compete in quality and price both in domestic and world markets.

The industry must be market-oriented if it is to succeed. Whenever feasible it should be an integrated agro-industry based on efficient, large-scale production of raw materials. Raw materials should be produced for processing directly into consumer items and also as ingredients for other human foods and as feedstuff for animals.

Financing the UNIDO programme

The programme of UNIDO for the promotion of the food-processing industry is financed under various United Nations operational programmes in which UNIDO participates, including: the Regular Programme of technical assistance devoted to industry and financed from the United Nations budget; the Special Fund component of the United Nations Development Programme (UNDP/SF); and the Technical Assistance component of the United Nations Development Programme (UNDP/TA). UNIDO receives, in addition, voluntary contributions from Governments for the financing of the Special Industrial Services programme (SIS), a programme limited largely to urgent short-term missions. Some projects may also be financed from funds in trust, deposited by Governments for specific projects, or other direct voluntary contributions. In all these programmes assistance is given only at the request of the Government concerned.

Co-operation between UNIDO and FAO

UNIDO's responsibility for industrialization in the field of food processing has been formally defined in an agreement which sets the guidelines for co-operation with FAO. UNIDO has responsibility for the equipment, engineering, chemical and managerial aspects of the food-processing industry. Because of its general responsibilities for industrial development and for receiving and promoting the work of the United Nations family in the field of industrialization, UNIDO also has responsibilities for general economic aspects of the food industry. These include sound development of the industry in a given country in line with the requirements of the industrialization process as a whole.

Origin and classification of projects

UNIDO projects in the food-processing industry originate in three ways:

Through Government requests for technical assistance;

On recommendation of regional economic commissions of the Economic and Social Council of the United Nations;

Following resolutions adopted by the Industrial Development Board.

Projects are classified as follows:

Field-operational projects of technical assistance to developing countries;

Country survey and research studies in support of technical assistance in specific food-processing techniques and developments in tropical and sub-tropical countries;

Seminars and meetings of experts on practical problems of the food-processing industry in particular countries and regions;

Publications;

Promotional activities;

Activities in co-operation with regional economic commissions of the United Nations.

The areas in which UNIDO can be of assistance in promoting food processing are outlined in annex 1, together with a listing of projects which have been or are being implemented with UNIDO aid and those now under discussion.

Expert group meetings, seminars and working sessions organized by UNIDO are listed in annex 2. Publications relating to the field of food processing are published by UNIDO, as listed in annex 3.

Projects assisted in 1968 and 1969

Although UNIDO, having been newly formed, was just gathering momentum in 1968, more than 50 specific food-processing projects were on its programme that year. Assistance was given to 33 countries for many different types of food-processing operations. Two of the projects have been carried over to 1969: one for assistance in research and personnel training in an African country, and one for a study of the existing food industry in a Far Eastern country, with emphasis on the development and evaluation of food industry projects.

A dozen new food-processing assistance projects were on UNIDO's 1969 schedule. Four of them involved processing vegetable materials; two concerned meat plants; two were for fish processing; one for castor-oil processing; and three for animal feed production. Nineteen other food-processing projects were scheduled for assistance in 1969, including six for vegetable-oil plants; five involving agro-industry developments; two for modernization of wineries; three involving sugar technology; a pre-investment study for breweries; a project for dehydrating fruits and vegetables; and one project for the production of fish-protein concentrate.

Forty-four developing countries benefited from the 1969 projects—in Africa, Asia and the Far East, the Americas and the Middle East. The total costs of assistance in connexion with food processing is estimated at $1,460,000; 781 man-months of experts are involved. In 1970 it is foreseen that 214 experts in food processing will be employed for 1,800 man months and 99 fellows will be in training for 497 man-months.

The nature of UNIDO's activities

To facilitate the application of new expertise for the promotion of food processing, UNIDO has established co-operation in research with a well-known food-processing research centre in Europe—the Springer

Institute in Wageningen, the Netherlands. The Institute will provide research facilities for the experts of UNIDO and will organize a centre in the Netherlands for in-plant training in food processing.

As UNIDO's activities in food processing spread, the need has increased for specialists in a wide range of technical disciplines to handle assistance projects, and the recruitment of such specialists has become one of the important operations of the Organization.

UNIDO's programme of activity is realistically planned on the basis of direct contact with developing countries through technical assistance activity. UNIDO pinpoints its activities to achieve specific benefits. For example, a processing plant may relay a request for assistance through its Government to UNIDO, which responds by sending carefully selected experts to assist. If, for example, the problem involves pork-processing technology, a pork-processing expert will be sent, not a general meat expert or a beef-plant engineer. Action is joined with analysis in an approach that is both direct and logical.

An important UNIDO service is to assist in the selection of processes and equipment. Expertise in plant and process engineering is sorely needed in many of the developing countries. Assistance is also provided for the improvement and better use of raw materials and for the solution of other specific industrial problems.

Some technical aspects of UNIDO assistance relate to the basic processes and functions of food processing, such as dehydration, refrigeration, evaporation, sanitation, packaging and water and waste management. With the aid of consultants or expert groups, practical guidelines for the various functions are developed and published as manuals. (See annex 3 under UNIDO.)

In other specific aspects of its work, UNIDO concentrates on basic types of foods, e.g. proteins, carbohydrates, and fats and oils, or on various branches of the industry, e.g. meat packing, dairy processing, milling, fruit and vegetable preservation, and fish processing and frequently gives expert technical assistance to plants in these various branches.

UNIDO's activities are aimed simultaneously at fostering improvement in the supply of processed foods and in developing the economy of the countries assisted. The integration of the food-processing industry with agriculture serves both purposes: food is produced more efficiently, raw materials are effectively utilized, the need for imports is reduced, exports are generated, and associated industries and activities are developed. As a result, the country as a whole has more food, more jobs, and a better over-all economy.

Specific nutritional deficiencies are of primary concern to UNIDO, particularly the shortage of protein. Special emphasis is placed on the industrialization of protein production and processing, and UNIDO promotes research into new protein sources and new processes, putting high priority on fish-protein concentrates, on the isolation of soy protein, and on new techniques for producing protein from petroleum.

Better utilization of carbohydrate raw materials, such as cassava, is another target. The hope is to industrialize the production of special local dishes like gari and couscous, or combinations like fish paste with rice. Another possibility is to use cassava flour in bread. At the same time, there is a need to produce commercial products from starch for export.

More efficient production and utilization of food oils from the oilseeds, beans and nuts that are grown extensively in the tropics is another special concern of UNIDO, as is the manufacture of animal feed containing by-products of food processing such as oil cake.

UNIDO is involved in many supporting activities. Progress in food processing must be backed up by technical research, and economic surveys must be carried out to lay the foundation for purposeful technical projects and for the development of comprehensive national plans. UNIDO's responsibilities also include assistance in market evaluations, aid in financing projects, and help in training the necessary technical and management personnel.

Other monographs in this series deal with the various aspects of industrial development which affect all industrial sectors, e.g. industrial planning, engineering, manpower, research, standardization and quality control, marketing, small-scale industry and investment promotion.[a]

[a] The series of 21 monographs is listed on the back cover.

Annex 1

UNIDO ASSISTANCE IN THE FIELD OF FOOD PROCESSING

A. Areas relating to the development of the food-processing industry in which UNIDO is in a position to provide technical assistance

Policies and programmes for the development of various branches of the food-processing industry and industrial estates;

Planning, construction and management of industrial estates and industrial areas including agro-industry and agro-industrial combines;

Industrial surveys, feasibility and pre-investment studies;

Promotion of new enterprises and modernization of existing ones;

Financing;

Establishment and operation of institutions and servicing facilities, including research, marketing and extension services; assistance in technique and management;

Promotion of modern processing methods and standardization of processing equipment;

Training of entrepreneurs and workers;

Formulation of technical co-operation projects.

B. Selected major technical assistance projects

The projects listed below relate to the activities of the United Nations Industrial Development Organization since its establishment in 1967. The list excludes projects carried out under the predecessor organizations of UNIDO (the former Division of Industrial Development up to 1962 and the Centre for Industrial Development up to 1967). Since the projects are listed for illustrative purposes, the names of countries have been omitted. The respective programmes under which the projects are implemented are shown as:

SIS	Special Industrial Services of UNIDO
UNDP/TA	United Nations Development Programme, Technical Assistance Component
UNDP/SF	United Nations Development Programme, Special Fund
RP	Regular Programme

(1) *Projects implemented or under implementation by UNIDO in areas related to food processing*

AFRICA

Assistance to African meat market (RP)
Adviser on biscuits and pastries (SIS)
Canning and food processing (UNDP/SF)
Feasibility study for cassava industrialization (SIS)
Study of soluble coffee plant (SIS)
Tobacco processing and marketing (SIS)
Assistance to vegetable oil industry (SIS)
Assistance to a fish protein concentrate plant (SIS)
Industrial processing of maize (SIS)
Production of malt (SIS)
Fruit and vegetable processing industry (SIS)
Survey of edible oils and fats industry (SIS)
Establishment of a milling industry (SIS)
Assistance to a tuna fish project (SIS)
Soybean and cassava processing plant (SIS)
Cashew nut processing (SIS)
Alcohol production and marketing (SIS)
Animal feedstuff production (SIS)
Tomato canning industry (UNDP/SF)
Catgut manufacture (UNDP/TA)
Programme of agro-industrial development (SIS)
Pineapple canning project (SIS)
Assistance to a meat-canning plant (SIS)
Demonstration plant for fodder yeast (SIS)
Meat-processing industry development (SIS)
Training of nationals for food-processing plants (SIS)
Feasibility study for a castor oil factory (SIS)

THE AMERICAS

Assistance to edible oils industry (UNDP/TA)
Assistance to fruit-processing industry (SIS)
Assistance to vegetable oil processing industry (SIS)

THE AMERICAS *(continued)*

Assistance to marketing corporation (SIS)
Food industry development (SIS)
Processing technique for naranjilla (SIS)
Rationalization of the food industry (SIS)
Evaluation of the fishery industry (SIS)
Adviser on food processing (SIS)

ASIA AND THE FAR EAST

Food industry advisers (RP)
Wine technology adviser (UNDP/SF)
Assistance to oils and fats industries (SIS)
Assistance to the sugar industry (SIS)
Feasibility study for the production of agar-agar (SIS)
Fruit and vegetable processing and marketing (SIS)
Assistance to the rice-processing industry (SIS)
Food-processing industry (SIS)
Assistance to meat and milk industry (UNDP/TA)
Vegetable oil industry development (SIS)
Programme of agro-industrial development (SIS)

EUROPE AND THE MIDDLE EAST

Export sales promotion of integrated fish processing (SIS)
Citrus processing industry (UNDP/SF)
Production of liquid invert sugar from dates (SIS)
Assistance to brewing industry (SIS)
Study of tobacco industry (UNDP/SF)

(2) *Projects in preparation or under discussion with Governments in areas related to the development of the food-processing industry*

AFRICA

Assistance to flour-milling industry (SIS)
Sorghum and millet industrialization (SIS)
Dehydration of vegetables (SIS)
Assistance to meat industry (SIS)
Agro-industrial development (SIS)
Cashew nut processing industry (SIS)
Citrus fruit processing industry (SIS)
Industrial processing of millet (UNDP/SF)
Programme of agro-industrial development (SIS)
Assistance in cheese manufacturing (SIS)

THE AMERICAS

Assistance to food industry (protein production) (SIS)
Agro-industrial combine (SIS)
Banana flour project (UNDP/SF)
Tropical fruit and vegetable processing (SIS)

ASIA AND THE FAR EAST

Fish industry (SIS)
Assistance to the rice industry (UNDP/SF)
Establishment of a coconut research centre (UNDP/SF)
Feasibility study on modern rice milling and oil recuperation (SIS)

Annex 2

SEMINARS, SYMPOSIA AND WORKING GROUPS ORGANIZED BY UNIDO

	Location	*Date*
Seminar on Integrated Food Processing	Novi Sad, Yugoslavia	November 1968
Expert Group Meeting on Scientific Approaches to Problems of Preservation and Refrigeration of Food in Developing Countries	Vienna	February 1969
Expert Group Meeting on Soybean Processing and Use	Peoria, Ill., United States	November 1969
		Proposed date
Expert Group Meeting on Food Processing Equipment Normalization		1970
Expert Group Meeting on Industrial Processing of Cassava		1970
Expert Group Meeting on the Main Aspects of Industrial Vegetable Oils and Fats Production in Developing Countries	London	1970
Expert Group Meeting on Processing Selected Tropical Fruits and Vegetables for Export to Premium Markets		1971
Seminar on the Industrial Processing of Rice	Bangkok	1971

Annex 3

SELECTED LIST OF DOCUMENTS AND PUBLICATIONS ON FOOD PROCESSING INDUSTRY[1]

UNITED NATIONS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

Profiles of Manufacturing Establishments, 2 vols. (ID/SER. E/4 and 5) (Sales Nos.: 67.II.B.17 and 68.II.B.13).

Industrial Processing of Citrus Fruit (ID/SER. I/2) (Sales No.: 69.II.B.9).

The Use of Centri-therm, Expanding-flow and Forced-circulation Plate Evaporators in the Food and Biochemical Industries (ID/SER. I/1) (Sales No.: 69.II.B.14).

Water-Saving Techniques in Food-Processing Plants (ID/SER. I/3) (Sales No.: 69.II.B.16).

Milk Processing in Developing Countries (ID/SER. I/4) (Sales No.: 69.II.B.29).

Packaging, Packaging Materials and Techniques (ID/SER. I/5) (Sales No.: 69.II.B.31).

Production of Feedstuffs and Protein Enriched Mixtures and Concentrates (ID/SER. I/6) (to be published in 1970).

Report of Group Meeting on Scientific Approaches to the Problems of Preservation and Refrigeration of Food in Developing Countries (working title, to be published in 1970).

Report of Seminar on Integrated Food Processing (working title, to be published in 1970).

[1] Symbols and Sales Numbers of United Nations documents and publications are given in parentheses after the titles.

Food and Agriculture Organization

Some Aspects of Food Refrigeration and Freezing, 1950 (Agricultural Studies No. 12).

Advances in Cheese Technology, by F. V. Kosikowski and G. Mocquot, 1958 (Agricultural Studies No. 38).

Milk Plant Layout, by H. S. Hall, Y. Rosén and H. Blombergsson, 1963 (Agricultural Studies No. 59).

Milk Sterilization, by H. Burton, J. Pien and G. Thienlin (Agricultural Studies No. 65).

Equipment for the Processing of Rice, by A. Aten, A. D. Faunce and L. R. Ray, 1953 (Agricultural Development Papers No. 27).

Meat Handling in Underdeveloped Countries: Slaughter and Preservation, by I. Mann, 1960 (Agricultural Development Papers No. 70).

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Christensen, C. M. and H. H. Kaufmann, *Grain Storage* (role of fungi in quality loss), University of Minnesota Press, Minneapolis, Minn., 1969.

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Woodroof, J. G., *Tree Nuts: Production, Processing, Products*, Avi, Westport, Conn., 1967.

UNIDO MONOGRAPHS ON INDUSTRIALIZATION OF DEVELOPING COUNTRIES: PROBLEMS AND PROSPECTS

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