UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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Monographs on Appropriate Industrial Technology
No. 7

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR FOOD STORAGE AND PROCESSING

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EXPLANATORY NOTES

A full stop (.) is used to indicate decimals.

A comma (,) is used to distinguish thousands and millions.

A slash (/) is used to indicate "per", for example t/a = tonnes per annum.

A slash between dates (for example, 1979/80) indicates an academic, crop or fiscal year.

A dash between dates (for example, 1970–1979) indicates the full period, including the beginning and end years.

References to dollars ($) are to United States dollars.

References to rupees (Rs) are to Indian rupees. In October 1978 the value of the rupee in relation to the dollar was $1 = Rs 7.90,

The word billion means 1,000 million.

The word lakh means 100,000.

The following notes apply to tables:

Three dots (. . .) indicate that data are not available or are not separately reported.

A dash (–) indicates that the amount is nil or negligible.

A blank indicates that the item is not applicable.

Totals may not add precisely because of rounding.

In addition to the common abbreviations, symbols and terms and those accepted by the International System of Units (SI), the following have been used:

Commercial terms

GDP	gross domestic product
GNP	gross national product
NPV	net present value

Organizations

AFDC	Agricultural Food Division Council
ASCI	Administrative Staff College of India
ASEAN	Association of South-East Asian Nations
ASRCT	Applied Scientific Research Corporation of Thailand
CWC	Central Warehousing Corporation
FAO	Food and Agriculture Organization of the United Nations
FCI	Food Corporation of India
FIIR	Federal Institute of Industrial Research
IGSI	Indian Grain Storage Institute
ILO	International Labour Organisation

EXPLANATORY NOTES *(continued)*

IRRI	International Rice Research Institute
ISI	Indian Standards Institute
KCMPU	Kaira Co-operative Milk Producers Union
NCA	National Commission on Agriculture
NORAD	Norwegian Agency for International Development
SWC	State Warehousing Corporation
TISI	Thailand Industrial Standards Institute
TPI	Tropical Products Institute
UNICEF	United Nations Children's Fund
WHO	World Health Organization

Technical abbreviations and symbols

acre	(1 acre = 0.4 ha)
CAP	cover and plinth
FFA	free fatty acid
quintal	100 kilogram
R and D	research and development
tce	tonnes of coal equivalent

The concept of appropriate technology was viewed as being the technology mix contributing most to economic, social and environmental objectives, in relation to resource endowments and conditions of application in each country. Appropriate technology was stressed as being a dynamic and flexible concept, which must be responsive to varying conditions and changing situations in different countries.

It was considered that, with widely divergent conditions in developing countries, no single pattern of technology or technologies could be considered as being appropriate, and that a broad spectrum of technologies should be examined and applied. An important overall objective of appropriate technological choice would be the achievement of greater technological self-reliance and increased domestic technological capability, together with fulfilment of other developmental goals. It was noted that, in most developing countries, a major development objective was to provide adequate employment opportunities and fulfilment of basic socio-economic needs of the poorer communities, mostly resident in rural areas. At the same time, some developing countries were faced with considerable shortage of manpower resources; in some other cases, greater emphasis was essential in areas of urban concentration. The appropriate pattern of technological choice and application would need to be determined in the context of socio-economic objectives and a given set of circumstances. The selection and application of appropriate technology would, therefore, imply the use of both large-scale technologies and low-cost small-scale technologies dependent on objectives in a given set of circumstances.

Report of the Ministerial-level Meeting, International Forum on Appropriate Industrial Technology

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Foreword

As part of its effort to foster the rapid industrialization of developing countries, the United Nations Industrial Development Organization (UNIDO), since its inception in 1967, has been concerned with the general problem of developing and transferring industrial technology. The Second General Conference of UNIDO, held at Lima, Peru, in March 1975, gave UNIDO the specific mandate to deal in depth with the subject of appropriate industrial technology. Accordingly, UNIDO has initiated a concerted effort to develop a set of measures to promote the choice and application of appropriate technology in developing countries.

Appropriate industrial technology should not be isolated from the general development objective of rapid and broad-based industrial growth. It is necessary to focus attention on basic industrial development strategies and derive from them the appropriate technology path that has to be taken.

The Lima target which, expressed in quantitative terms, is a 25 per cent share of world industrial production for the developing countries by the year 2000, has qualitative implications as well. These comprise three essential elements: fulfilling basic socio-economic needs, ensuring maximum development of human resources, and achieving greater social justice through more equitable income distribution. Rapid industrialization does not conflict with these aspirations; on the contrary, it is a prerequisite to realizing them. But, in questioning the basic aims of development, we also question the basic structure of industrial growth and the technology patterns it implies.

Furthermore, it is easy to see that the structure of industrial growth that should be envisaged and the corresponding structure of technology flows should be different from what they are today; a fresh approach is called for. This does not mean that the flow of technology to the modern sector and the application of advanced technologies are unnecessary. On the contrary, it is essential to upgrade the technology base in general, and it is obvious that to provide basic goods and services, there are sectors of industry where advanced or improved technology is clearly necessary. It would be difficult to envisage a situation where the dynamic influence of modern technology is no longer available for industrial growth and development in general. However, an examination of the basic aims of industrial development leads to the conclusion that there must be greater decentralization of industry and reorientation of the design and structure of production.

Such decentralized industry in the developing countries calls for technologies and policy measures that often have to be different from those designed for the production of items for a different environment, that of the developed countries. As a result, there is a two-fold, or dualistic, approach to an industrial strategy. Morever, the two elements in such an industrial strategy need to be not only interrelated but also integrated.

In approaching the question of appropriate industrial technology from an examination of basic development needs, a mechanism is necessary to link and integrate appropriate industrial technology to the overall development process. Through such a process the concept of appropriate industrial technology could be placed in the mainstream of the industrial development effort.

It is hoped that these monographs will provide a basis for a better understanding of the concept and use of appropriate industrial technology and thereby contribute to increased co-operation between developing and developed countries and among the developing countries themselves.

It is also hoped that the various programmes of action contained in the monographs will be considered not only by the forthcoming meetings of the United Nations Conference of Science and Technology for Development and UNIDO III but also by interested persons working at the interface over the coming years.

Abd-El Rahman Khane
Executive Director

Preface

To focus attention on issues involved in choosing and applying appropriate technology, UNIDO organized the International Forum on Appropriate Industrial Technology. The Forum was held in two parts: a technical/official-level meeting from 20 to 24 November 1978 at New Delhi and a ministerial-level meeting from 28 to 30 November 1978 at Anand, India.

In response to a recommendation of the ministerial-level meeting, UNIDO, with the help of a generous contribution by the Swedish International Development Authority, is publishing this series of monographs based mainly on documents prepared for the technical/official-level meeting. There is a monograph for each of the thirteen Working Groups into which the meeting was divided: one on the conceptual and policy framework for appropriate industrial technology and twelve on the following industrial sectors:

Low-cost transport for rural areas
Paper products and small pulp mills
Agricultural machinery and implements
Energy for rural requirements
Textiles
Food storage and processing
Sugar
Oils and fats
Drugs and pharmaceuticals
Light industries and rural workshops
Construction and building materials
Basic industries

The monograph on the conceptual and policy framework for appropriate industrial technology also includes the basic part of the report of the ministerial-level meeting and some papers which were prepared for the Second Consultative Group on Appropriate Industrial Technology, which met at Vienna, 26-29 June 1978.

PART ONE

Issues and considerations

Note by the secretariat of UNIDO

I. FOOD STORAGE

Introduction

More than 50 per cent of the energy consumed by humans as food comes from food grains. This paper therefore concentrates on food-grain storage, since the amount of energy contained in food-grains can be severely reduced by unscientific storage practices.

Storage technology can be broadly divided into three categories according to the place at which it is applied: the farm, where farmers retain grain for their own use; the village or community, where facilities are operated on a co-operative basis; and the city, where as much as 30 per cent of the grain produced may be stored. There is a growing awareness that there is a need to build adequate storage facilities in all three categories within the developing countries and that whatever techniques are used, they should be compatible with existing infrastructural facilities and should be particularly related to marketing and distribution arrangements.

On the farm, storage facilities built in traditional style would be owned and operated by individuals, many of whom cannot afford to improve them. However, when practical, collective storage facilities in communities could incorporate technological improvements, which would also facilitate replacement of existing private intermediaries in the procuring, storage, marketing and distribution of food grains, who are known to exploit the farmers' lack of capacity and financial resources to stock grain.

Objectives

The objectives of providing suitable storage facilities for food grains are these:

(a) Conservation of food grains by minimizing qualitative and quantitative post-harvest losses;

(b) Attainment of self-sufficiency in food-grain requirements;

(c) Regulation and possibly replacement of private intermediaries in procurement, handling, storage and distribution;

(d) By the establishment of public-sector storage facilities: (i) Stabilization of consumer prices and protection of the interests of low-income groups; (ii) Assurance of reasonable prices to producers as an incentive for increased production (price support); (iii) Maintenance of stocks as a buffer against periodic and unforeseen shortages and consequent high prices;

(e) By R and D: (i) An increased use of local raw materials in building storage facilities of different scales and design suited for different purposes, especially on farms and in villages; (ii) Development or adaptation of technologies that farmers can afford to install and use;

(f) Generation of increased employment opportunities in the building of low-cost structures at the farm and village levels.

II. REVIEW OF ALTERNATIVE TECHNOLOGIES

Quantitative and qualitative losses of food grains

Post-harvest losses in threshing, drying, transport and storage are estimated to be from 20 to 40 per cent. Storage losses alone are about 5 per cent. Thus, when examining the storage technology of food grains, due attention should be paid to related post-harvest practices.

The qualitative losses are chiefly the destruction of vitamins by over-exposure to sunlight and to high temperatures in artificial drying; presence of mould, which grows in inadequately dried grain; and the effects of attacks by insects and pests that can enter deficient storage facilities. There could also be protein loss in pulses.

The losses can be minimized by taking appropriate measures in the post-harvest handling of the grains. Appropriate storage technology would call for equipment of the proper scale and type, the use of fumigation and other measures to control insects, fungi and rodents.

Storage practices and improvements in technology

On the farm

The storage losses that occur on farms are reported to be higher than elsewhere. Some of the most common indoor and outdoor structures used for storage on farms are made of mud and split bamboo; in them the grain is usually damaged by insects, fungi and rodents. The structures cannot be effectively fumigated. Some of the indoor bins that are being built are metal bins, structures of burnt bricks plastered with cement, welded wire-mesh bins, and paddy straw and mud structures. The outdoor bins are constructed of metal and brick and appear as flat- and hopper-bottom metal bins, composite bins and reinforced brick bins. They can be hermetically sealed and placed underground or partly above ground. The capacity is about 500 kg.

In villages

The bins used in villages are either circular or square, with capacities ranging from 500 to 1,000 kg, made of standard sizes of galvanized-iron sheets. The height may be from 0.5 to 1.0 m. The circular bins are easy and economical to fabricate, while the square ones are convenient to keep in the corner of a building. The average life of metal bins is said to be over 20 years.

Bins can also be made of ferrocement, high-density polythene and wood.

Ferrocement bins are made of cement mortar and closely spaced wire mesh in capacities ranging from 0.6 to 3.0 t. They are cylindrical and have flat bottoms and domed roofs. Wall thickness is normally 25 mm.

In cities

In most developing countries food grains are handled, transported and stored in bags. Accordingly, the entire marketing and storage system is based on bag handling. It is said that the system inhibits the adoption of the advanced technologies of bulk storage widely practised in developed countries. The bulk-storage facilities that are known to exist are conventional godowns for storage in bags, steel silos, reinforced concrete circular, hexagonal and vertical bins, and cover-and-plinth open-storage. The standard basic unit of capacity of conventional godowns (flat warehouse) is 5,000 t.

The background paper "Appropriate technology for food grain storage under Indian conditions" in this monograph includes an analysis of problems related to food-grain storage in general, on the farm, and by public agencies. The authors estimate that the investment cost per tonne of stored grain capacity is $50 for conventional godowns, $150 for inland bulk-storage structures and $300 for high-turnover port facilities. Another analysis of appropriate technologies for food-grain storage is presented in the background paper "Technological choice and employment in food processing and storage and related policy issues".

Pest-control methods

In traditional methods of storage, fumigation is used to prevent fungal and insect attack. The irradiation of food grains and crops can be considered as an alternative technique. Apart from guarding against losses during storage, there is a need to develop methods to preserve seasonal and perishable commodities for longer periods so as to extend their availability at low cost and to meet the nutritional requirements of the population. Unlike fumigation, irradiation is effective in killing or sterilizing insects in all parts of their life cycle and leaves no toxic residue. Low-dose irradiation also effectively inhibits sprouting in onions and potatoes, significantly reducing losses, and presents an alternative to costly cold-storage facilities. Radiation-induced delay in ripening extends shelf-life and improves marketability. This is also true for the preservation of seafood. The only question to be settled is whether the technology can be considered to be adequately free of health and environmental hazards.

Policy implications of alternative techniques

Food-grain storage by public agencies

Government storage facilities are required, not only for holding buffer stocks, but also as part of food-grain procurement and distribution.

The choice and appropriateness of the technique depend upon how much is to be stored and for how long. In well-designed structures, grains can be stored for 4–5 years. (See the two papers referred to above, for comparative analyses of techniques.)

Extension service in the storage of food grains

In food-grain storage, low-cost improvements to traditional systems may be appropriate on the farm and in villages but are difficult to apply widely. An effective extension service to assist farmers in improving their traditional storage techniques and also in building community storage facilities is necessary.

The elements of a comprehensive extension service should include the following four factors: *(a)* Financial support to farmers and communities; *(b)* Dissemination of information on alternative storage techniques; *(c)* Provision of designs and guidance in construction; *(d)* Subsidies to meet the requirements of the less affluent sections of the community.

Marketing

The nature of the marketing and distribution systems, including the availability and mode of transport, have a bearing on the choice of storage in terms of quantity and type of grain and on the duration of storage.

Establishing institutional arrangements for post-harvest technology

There should be an institutional arrangement at the national level for dealing with post-harvest problems, directing technological development and guiding extension services. Such an arrangement could take into account not only the post-harvest problems associated with storage, but also those associated with threshing, transport, packaging and handling. Assistance in the use of indigenous materials for construction and the adaptation of known technologies and extension services should be a government responsibility. Interdepartmental and interinstitutional collaboration would be required, and suitable measures would be called for to co-ordinate the widely dispersed activities within the country in the effective implementation of a post-harvest technology programme. The degree of government regulation that can be enforced to ensure suitable storage at various levels of marketing should also be considered. The regulations for storage facilities should require regular inspection of the means used to prevent qualitative and quantitative losses.

The institutional arrangement would undertake R and D activities, extension services and technical assistance. Institutional arrangements could be established to serve as intermediaries between producers and consumers, assist in pricing farm products and organize the distribution of grains.

The role of international co-operation

International co-operation would be of value in the following activities:

(a) Collecting, compiling and disseminating information on and experience in various types of storage techniques;

(b) Monitoring and updating different types of storage under different conditions;

(c) Exchanging experience and information on the use of various types of pesticides and preservation techniques, including irradiation;

(*d*) Increasing the effectiveness of the R and D activities in some of the developed countries in relation to situations prevailing in specific countries.

Organizations in United Nations family and other international organizations could assist greatly in the collection, analysis and dissemination of information on appropriate storage techniques and practices.

Through their aid programmes, developed countries could assist developing countries in building storage facilities for food grains in all three categories (farm, village and city) by providing both expertise and financial assistance.

II. FOOD PROCESSING

Introduction

The food-processing industries account for more than one fifth of all the manufacturing activities of the developing countries and represent 58 per cent of the value added by all industries that process agricultural raw materials in the developing countries. In 1976, the value added in food processing in the developing countries represented 14.6 per cent of the total value added in the world, which is considerably higher than their overall share of world manufacturing value added (about 8.6 per cent).

The average annual growth rate of employment in food processing for the period 1960–1973 was 3 per cent for the developing market economies, a figure that is considered to be low. One of the major reasons for the slow growth has been the inadequacy of physical links with agriculture. The lack of agricultural raw materials has inhibited the expansion of output and export of the food-processing industries. Shortages of agricultural raw materials has led to excess capacities in the food-processing industries in a number of developing countries.

It is possible that fluctuations in the supply of agricultural raw materials to industry may be rectified by establishing closer organizational links between industry and agriculture. Agro-industrial complexes with integration of food-processing industries and agriculture would provide industrial support for agricultural development and would be of interest in special circumstances.

Food-processing industries provide the most favourable stimulus for the manufacturing sector. Its growth implies the expansion of all activities that supply inputs to it. Parallel improvements in infrastructure, transportation, storage and marketing are prerequisites for expanding it.

Any decentralization of food-processing industries to make them viable and to serve social objectives would call for structural changes and would have policy implications. Foreign investment in food industries and the operation of transnational corporations in a number of developing countries are well known. Simple and adaptive food-processing technologies have been developed and are being used in some developing countries. The manufacture of capital goods has been undertaken to varying degrees in the developing countries, the constraints being the level of development of the design and engineering capabilities and the limited markets for such equipment and machinery.

Objectives

The principal objectives of developing the food-processing sector would appear to be the following:

(a) Meeting the food and nutritional requirements of the population;

(b) Reduction of qualitative and quantitative losses of agricultural products by bringing industrial processing nearer to the sources of production;

(c) Augmenting foreign-exchange earnings by the export of processed products rather than of raw materials or semi-processed products;

(d) Dispersal of industrial growth to underdeveloped and rural areas so as to generate employment opportunities;

(e) Creation of opportunities for greater national ownership of production units;

(f) Stimulation of technological development and capabilities in terms of alternative scales and technologies for processing a variety of food products;

(g) Development of engineering design and capability to manufacture food-processing and ancillary equipment and stimulate the development of industries that would provide inputs to the food-processing industries.

Review of alternative technologies

Technologies in five important sectors

Since food processing covers many activities, attention is concentrated here only on five sectors that are of special importance to a large number of developing countries, namely: rice milling, breadmaking, fruit and vegetable preservation, milk processing and fish preservation. The analysis of the problems in these industries with reference to decentralization should provide some basis for policy decisions on choices of technology in the food-processing industries as a whole.

Rice milling

In the background paper: "Technological choice and employment in food processing and storage and related policy issues", the alternative technologies for rice milling examined are hand-pounding, with its improvements; power-driven rice mills of the steel-roller type, using 10 to 15 hp (7.5 to 11 kW) engines; one-pass Japanese rubber roller mills with higher rice recovery; and large mills with threshers, dryers and bulk storage facilities and with capacities of 2 t/h and integrated mills with capacities of 25 t/h.

An important issue for consideration is the extent of and alternatives to the mechanization of rice milling. While employment is an important consideration, it would also seem that the mechanization of rice milling is necessary in the interest of higher output, fewer broken grains and recovery of bran free from husks.

The establishment of mini mills using the rubber-roller sheller system would still serve the purpose of decentralization of the rice-milling industry.

Technological improvements should take into account the following considerations:

(a) Parboiling the paddy to conserve its vitamins, harden the grain and reduce the proportion of brokens;

(b) Mechanical drying of the paddy, using paddy husk as fuel;

(c) Use of rubber roller sheller to minimize grain breakage;

(d) Utilization of husks as fuel for boilers and dryers and as raw material for products such as cement;

(e) Extraction of oil from bran, with stabilization facilities if feasible.

Breadmaking

Bread is the most important product derived from food grains. Breadmaking ranges over an extraordinarily wide scale: from one-person bakeries to large-scale automated factories. As a staple, its composition must closely match local food preferences and its nutritional value must be adequate: the improvement of traditional local products and processes rather than the introduction of foreign ones is what is needed in most cases. Such a situation would, for instance, apply to the manufacture of unleavened bread in the Middle East.

Doughmaking constitutes the first stage in the manufacture of leavened bread. Activated dough is an innovation that would suit small-scale breadmaking. Its introduction has also created a new option in industrialized countries, where breadmaking processes have tended to increase in scale. The activated dough process, with its small-scale ovens and nutritional improvement, would be a technological option worth considering for stimulating leavened breadmaking industries in developing countries also.

Fuel economy is a significant factor in oven design. When wood is the fuel, for instance, the energy consumption per unit of processed flour is relatively high. Research in oven design or the use of other types of fuel or both is needed.

Fruits and vegetables

The durability of fruits and vegetables, which are important as a natural source of vitamins and minerals, can be enhanced by the use of preservatives. Preservation processes are of many kinds: simple drying, the use of natural preservatives (salt, vinegar), canning (with sterilization and the use of selected preservatives), freezing and freeze-drying (the latter requiring a highly developed refrigeration technology).

The improvement of durability also extends the market for fruits and vegetables, linking rural areas with urban centres, as well as with overseas markets. These market demands will pose specific requirements as regards plant, equipment, facilities and management. In long-distance transportation and storage operations, a backward-extending technology has emerged by which, for certain products, the need for preservation can be eliminated by incorporating, under controlled storage conditions, a part of the final stage of the plant-growth process, e.g., the ripening of bananas.

Local demand, export markets, the improved use of agricultural resources, employment, investment, costing and profitability considerations constitute the primary criteria by which, in a given situation, the choice of technology is to be made.

Milk processing

Milk production and processing is a traditional activity in a large number of developing countries. In addition to providing protein foods, the dairy industry is to be seen as a typical rural activity that can bring about the technical, economic, social and cultural transformation of rural areas. The development of the dairy industry in the co-operative sector at Anand, India, is a case in point.

A workshop on integrated dairy industry organized at the Kaira District Co-operative Milk Producers Union at Anand, India, in April 1978 brought to light the advantages that have accrued in the breaking down of social barriers and the creation of an understanding of rural sanitation, birth control and family planning. The quality of life of the rural people depended to a large extent on the co-operative attitude they developed towards the restructuring of their society. The Anand example has amply demonstrated the immense beneficial effects of a co-operative dairy industry to the farmers.

The production of milk powder is to be considered from two aspects: as a preservative technique for surplus milk and, more important, as a deliberate effort to meet the nutritional requirements for protein food in remote areas where no milk is produced.

The issue is therefore to consider the development of the dairy industry as a part of an integrated rural development programme in the interest of income generation and making available a source of valuable protein food to malnourished people in rural areas.

Fish preservation

Fish provides less than 0.2 per cent of world food energy requirements but accounts for about 20 per cent of the animal protein in the human diet. Improvements in fish preservation would make available larger quantities of a valuable source of protein. Smoking, drying, salting and canning are the best known techniques. Analysis of alternative techniques has led to the conclusion that smoke drying is the most appropriate technique for fish preservation for distant inland markets. Canning has been ruled out as being energy intensive. It is further argued that smoke drying also provides greater employment opportunities and has lower investment costs.

To promote decentralization, it has been suggested that even where conditions permit large-scale fisheries with geographically concentrated landings, the catch could be turned over to a cluster of small smoke-drying and salting enterprises adjacent to the fishing harbour rather than to a large cannery. It should be noted, however, that when fish is to be preserved or processed for export, more sophisticated technologies than smoke drying are indicated.

Recycling the by-products and wastes of the food processing industry

Two goals could be achieved simultaneously through a rational management of agricultural and agro-industrial residues: *(a)* fewer residues, by encouraging and promoting more efficient processes; *(b)* less discharge into the environment, by the greater use and recycling of residues. The residues are usually amenable to biological, chemical and physical processes for conversion into energy, food, animal feed, organic fertilizers, construction materials etc. Some examples are the by-products and wastes of the processing of cereals, fruits and vegetables, cellulosic plants, oil-seeds, sugar and starch roots and tubers, fish, meat and beverages. When examining alternative technologies for food-processing industries, one should also examine the benefits of recycling the residues and the measures that should be adopted for their exploitation.

Policy implications

The policy issues arising in the five cases discussed above are as follows:

(a) Rice milling. A phased policy of mechanization should be followed with regard to better yields of grain and by-products;

(b) Breadmaking. There should be consideration of the production of activated doughs which would permit baking in small-scale units. Also, bread should be recognized as a convenience food that could be nutritionally enriched;

(c) Fruit and vegetable preservation. Although small-scale drying appears to be the appropriate technique and is cheaper than freezing or canning, alternative techniques should be considered to meet particular market demands and especially the requirements of export markets;

(d) Milk processing. Small-scale dairy industries in the co-operative sector would bring benefits to rural communities. The question is one of policy decision to develop the dairy industry as part of an integrated rural development programme;

(e) Fish preservation. Small-scale drying should be encouraged as being more labour intensive and less costly. Hower, this option excludes preservation and processing for exports, which would call for more sophisticated techniques.

The policy measures call for extensive development and promotion of technologies for much wider application of appropriate techniques already known and used and conscious efforts to reduce energy consumption.

An important policy consideration would be to take positive measures to develop and popularize indigenous products that would meet the requirements of most of the population. An issue to be considered is the nature of the disincentives needed to discourage the use of inappropriate techniques and products designed to cater to non-essential demands. It is important that there be a predominance of national ownership of the capital invested.

To strengthen national technological capability, a continuous search of alternative technologies and their appraisal and maintenance of inventories of up-to-date knowledge of a range of imported and domestic technologies is suggested. A mechanism to provide a pool of technical knowledge and information for advice and assistance to Governments in taking policy decisions would be necessary.

The role of international co-operation

International co-operation is essential in the accumulation of information on the choice of technology in food-processing industries. Specially, developing countries should be aided in the preparation of inventories of technologies of the food-processing industries that are of interest to them.

Food research and technological institutes in both developed and developing countries may be identified with a view to considering the use of technical assistance and advisory services in specified food-processing activities.

Co-operative R and D projects could be supported for the further improvement of existing appropriate techniques in industries such as rice milling, breadmaking, fruit and vegetable preservation, milk processing and fish preservation.

An interinstitutional network for the exchange of experience, research, design and engineering activities, infomation dissemination and the promotion of technical co-operation among developing countries at the regional or subregional level could be considered.

Report of the Working Group

I. FOOD-GRAIN STORAGE

General considerations

The problems involved in food-grain storage, which is a necessary part of post-harvest technology, may be classified according to the three distinct places at which it is used: the farm, for extended personal consumption; the village, by producers, traders or middlemen; and the city, including the storage facilities set up by public agencies to meet the requirements of the urban population.

Improvements should be brought about in techniques and equipment (using straw, bamboo and other indigenous raw materials) by the introduction of lined pits and cribs, large plastic storage bags and metal bins. Low-cost loans should be made available to farmers who cannot afford such improved storage equipment. The construction of lined structures could provide local employment.

Among the alternative storage technologies in villages and cities, bag and flat-bulk storage (godowns) are by and large the most appropriate techniques in the developing countries. As regards the duration of storage, food grains can be stored in the traditional way for a maximum of one year. With appropriate treatment in flat-bulk structures and godowns they can be stored for two or three years, in modern silos, for five years or even longer. The cover-and-plinth method of open storage of food grains in bags, which has proved to be useful for storage for short durations, especially in times of emergency, may be a good alternative in certain circumstances.

The use of vertical silos is very limited in developing countries because of their high capital and operational costs and because the traditional handling and marketing methods used are inadequate for silo storage. The lack of the bulk transport facilities commonly used in developed countries would also make vertical silos unsuitable, except for the storage of large quantities of food grains, as in ports for export or import or for the holding of buffer stocks for long periods. The storage of grains in large-capacity processing units would, however, call for modern storage godowns.

Losses from insect attack, fungal infestation and the depredations of birds and rodents constitute one of the basic problems of food grain storage in developing countries. Great care should be exercised in the use of pesticides so as to protect the environment and safeguard human and animal health. The use of traditional local materials such as lime, ashes, vegetable oils and activated clays could be further investigated.

The use of radiation for food preservation will increase dependence on developed countries, because the equipment is expensive, has to be imported and skilled personnel are required to operate it. Even after irradiation, suitable storage facilities would be required, which itself is a constraint. From the point of view of health safety, the value of this process is debatable; in the United States of America its use has been discontinued for some products. Furthermore, the technology involves large-scale facilities and high capital costs that may be justified only above certain minimum levels of grain input.

There is a need for sustained extension services to motivate the farmers and for appropriate institutional, financial and technical support to enable them to adopt improved storage techniques and priorities.

Due attention should be paid to grain drying. Technical improvements in this field include better designs for husk-fired dryers, the use of simple solar dryers and the application of biogas.

Adequate institutional supportive measures for post-harvest technology in respect of food grains and other crops involving threshing, drying, transport, packing and storage operations, research and development (R and D) activities, training, information and extension services are all necessary to improve the food-grain storage technologies in developing countries.

Policy

Measures needed to improve food-grain storage technology in developing countries include the following:

(a) Suitable institutional arrangements in each country to deal exclusively with post-harvest technology problems and to facilitate the effective co-operation of all related activities generally dispersed in a number of official and non-official agencies. Additionally, a separate R and D institute could be established, depending on the actual needs. Among other functions, such an institute should study the problem of post-harvest losses of food grains at the various stages of threshing, handling, drying and storage, with a view to taking remedial measures to reduce such losses and to undertaking cost-benefit studies on various alternative technologies for the levels of storage required within the country;

(b) The dissemination of information on technology development, application and adoption, and technical support to extension services, would be other important functions of the institute. When required, it could either undertake R and D activities within its own competence or subcontract problems to known institutions within the country to solve specific problems identified in the field and develop suitable post-harvest equipment;

(c) National research institutes, agricultural universities, extension services and the like could provide further institutional support for improving the technologies used in food-grain storage and other post-harvest operations such as drying and for the integration of transport with storage;

(d) Establishment of mobile demonstration units with a view to demonstrating the use of a package of post-harvest technologies tailored to the needs of small farmers may be an effective instrument of propagating improved storage methods. Assistance could also be provided in undertaking the local manufacture of post-harvest equipment;

(e) Existing traditional and indigenous storage structures and practices should be modified in a way that would reduce the losses and still be within the financial means and other resources of the farmers to adopt the improvements;

(f) Bulk centralized storage of food grains should be resorted to only for exceptional purposes, such as export or for holding large buffer stocks for periods of three to five years in areas where there is a shortage. Pre-processing storage of grain would also call for bulk-storage facilities. Under special circumstances where the bulk storage of food grains is required, vertical silos might not be advisable because of their high capital and operational costs. Alternative flat bulk-storage structures could be equally effective with less capital investment;

(g) A suitable financing mechanism would need to be established to assist the farmers, especially the small and medium-scale farmers, to adopt improved, appropriate technologies for storage and other post-harvest operations. Such a measure would call for suitable policy decisions to provide credit facilities. Equal importance would have to be given to other infrastructural requirements such as marketing and transport facilities;

(h) The national institutes to be established should actively seek the farmers' participation so as to make their activities effective and also to ensure the acceptance of the techniques developed and their practical application by the farmers;

(i) The extension services should have close links with R and D institutes and should be managed wherever possible by farmers' co-operatives or associations. The extension agent should not be a specialist but should rather be a generalist who would be able to assist the farmers in the entire range of farm activities. Facilities should be provided to update the knowledge of the extension agent from time to time.

The role of international co-operation

There is considerable scope for fruitful co-operation between developed and developing countries and among the developing countries themselves. The following measures may be considered in this respect:

(a) Emphasis should be laid on training in post-harvest technology, on the collection and dissemination of information, and on the exchange of experience and personnel among countries. The developed countries could provide assistance in the application and adaptation of technologies suited to the needs of individual developing countries;

(b) Considerable expertise and appropriate technologies have been developed in some of the developing countries. Technical co-operation among developing countries should be strengthened to facilitate exchange of experiences;

(c) Seminars, workshops and regional expert consultations should be organized to promote international co-operation and facilitate exchange of experiences between developed and developing countries and between developing countries themselves.

II. FOOD-PROCESSING INDUSTRIES

General considerations

Apart from the objectives of development of food-processing industries in developing countries discussed in the Note by the secretariat, it is also important to ensure fair financial returns to farmers and fishermen for their products.

Basic infrastructural requirements such as transport, credit, marketing, warehousing and institutional arrangements are needed to facilitate the development of the food-processing industries. Many developing countries lack adequate technical skills, equipment and management abilities. In the export of processed products, inadequate information on the export markets, lack of quality control, and tariff barriers have proved to be serious constraints on the industry.

In most developing countries the traditional skills and low levels of technology of the small-scale sector exist side by side with sophisticated technologies, and the development of the small-scale sector to produce low-cost products for mass consumption should be an important policy objective.

The priority areas that need attention include maintenance or even reduction of the cost of the products by increasing the efficiency of production so as to bring the products within reach of the masses; investigation of the nutritional qualities of food products so as to promote their consumption and thereby correct protein and caloric deficiencies of the poorer sections of the population; and generation of employment.

For an integrated development of agricultural raw materials production and food-processing activities, it is necessary to strengthen the interdependence and complementarity of industry and agriculture. In particular, industry should give increasing support to the development of agriculture, which in turn would provide it with raw materials.

The need for comprehensive institutional arrangements for the development, application, transfer and adoption of technologies suited to local conditions is an imperative necessity. The strengthening of indigenous technological capabilities for technological self-reliance should be the ultimate goal. Appropriate institutional arrangements should also be made for the collection, analysis and dissemination of technological information and for the introduction of training programmes.

For the prevention of losses of processed foods, preservation of quality, protection of consumers' interests, and the facility to export processed products and appropriate packing methods also need to be identified and propagated. Promotion of the use of indigenous raw materials for the packaging industry call for intensive R and D and suitable institutional support. Due care should be exercised in the choice of packaging technologies, so as not to add excessively to the cost of the end-product. In the tropics, traditional packaging techniques have been used for ages and are still in vogue for a variety of food products such as grains, fruits, vegetables and fish. Improved packaging technologies are essential, particularly for export. In this connection, the possibility of establishing national and regional packaging centres should be considered. Some developing countries have already established national packaging institutes to great advantage.

Policy

Energy needs of the food-processing industries should receive specific attention of the developing countries. Some industries like bakeries, khandsari sugar production and preservation of fruits and vegetables are large consumers of energy even in small-scale operations. Considerable research work is needed to improve the design of equipment with a view to reducing the energy consumption of these industries. Some methods of conserving energy which need immediate attention include the lagging of pipes and vessels to prevent heat loss from radiation and conduction; better methods of heat transfer; and more efficient plant layout to reduce the distances travelled by hot liquids and gases. In addition to the energy directly consumed in the production process, attention would also need to be given to improve the energy efficiency of packaging, most notably in canning.

With regard to the criteria for identifying priority products for the food-processing industries, the products selected should in general, be suitable for consumption by a large majority of the population and should be related to its needs and incomes. Suitable policy measures should be taken to discourage use of scarce resources for the production of items that are non-essential or that meet the requirements of only small or affluent sections of the population. However, the production of high-cost products even for domestic consumption should not altogether be ruled out, because in specific circumstances it might benefit the poorer sections of the population indirectly through creation of employment and income opportunities. In the case of milk products, the bulk of the employment created could be expected to occur in the agricultural sector, but in the case of breadmaking the process in itself could give significant employment opportunities if small-scale, labour-intensive technologies were used. Due care should be given to the introduction of products compatible with traditional eating habits.

A suitable government agency should be established in each country to co-ordinate the development of food-processing industries. Such an agency should include the representatives of such government departments as industry and agriculture, technologists, nutritionists, economists and social scientists. Such a mechanism would consider appropriate technologies both for export and high-cost products and for low-cost products.

In contrast to the organized large-scale industries, the small-scale units do not have the required expertise for the utilization of by-products and the conservation of energy. Therefore, it is the responsibility of the Government to provide the necessary technical assistance to these units through national R and D, extension services and adequate financial assistance.

The major problem of R and D consists in the upgrading of traditional and indigenous products. Modifications of such products and processes would be particularly valuable if they were to lead to the adoption of locally acceptable variants of low-cost traditional products. Scientific R and D has a great part to play in such modifications of products and processes. Upgrading and adaptation of the traditional technologies would be more relevant if it did not result in increase of cost of displacement of labour and if it increased the marketability and demand for the end-products.

When choosing technology in the rice-milling industry, care should be taken to ensure that mechanization does not lead to large-scale displacement of labour. However, hand-pounding technology is fast disappearing and small-scale mechanized processes have reduced drudgery, increased the quality and recovery of the grain produced and facilitated the utilization of by-products such as bran. Technological improvements like parboiling paddy, the utilization of husks as fuel and the use of rubber rollers in rice milling to prevent breakage of the grains and increase effective yield have received widespread acceptance in many developing countries.

In this context, there is a need to stabilize and use rice bran for the production of rice-bran oil of edible quality. R and D efforts need to be continued to develop low-cost and small-scale rice-bran stabilization units which the medium- or small-sized rice mills can afford to install and use.

With regard to products based on wheat flour, the most typical is the small-scale baking of traditional products by labour-intensive methods, which are reasonably appropriate for the foreseeable future. However, baking methods and techniques based on wheat imports from developed counties are widely in vogue in many developing countries. Nevertheless, if the expansion of this industry is to be justified, it must be on the basis of small-scale, labour-intensive and energy efficient technologies that can provide employment to the lower-income population and also make products acceptable to the local population.

The dairy industry should be included in an integrated rural development programme. The objective should be to generate income for landless labour and augment the income of farmers.

The rural employment potential of milk production and processing could be considerable, irrespective of the extent to which these products are consumed in rural areas.

The development of dairy industries in developing countries should not lead to the wasteful use of grains to produce animal feeds, as is the practice in developed countries. In some countries, for example, India, where the dairy industry has flourished for hundreds of years, the cattle are fed with agricultural wastes such as straw and by grazing the open lands.

The increased use, in these countries, of buffaloes, which give a better yield of milk for the input of straw and grass, is welcomed. In some developing countries the import of milk products at considerable expense represents a loss of foreign exchange. To reduce such imports, these countries have taken measures to develop their own dairy industries.

The development of a dairy industry in countries where it has particular advantages should be encouraged. For the lower-income population, the production of milk and its products corresponds to a cash-crop system, since it is a high-cost source of employment. The establishment of dairy industries should therefore always be judged in the context of alternative cash crops.

To ensure an orderly and sound development of the food processing industry, a national technological institute for food processing should be established in each country to direct and co-ordinate all R and D activities; advise the national Government on policies relating to development, application and transfer of technology; give technical assistance, education and training;

collect, analyse and disseminate information; and guide and support extension activities.

Positive measures should be taken for the promotion and wider applications of appropriate techniques already known and used, through exchange of information and experience mainly among developing countries.

An important policy consideration is to identify, develop and popularize indigenous low-cost products that meet the needs of most of the population. In this connection, use of fiscal and other disincentives as a matter of policy to discourage inappropriate techniques and products that satisfy non-essential wants should also be considered in certain circumstances. In strengthening national technological capabilities, a continuous search for, and appraisal of, alternative technologies and the maintenance of inventories of up-to-date knowledge on technologies in use is an imperative necessity. Such functions can be assumed by the proposed national technological institutes. The major function of these institutes would be to identify, select and adapt technologies from both the developed and developing countries in addition to developing innovative technological solutions for the processing of local products.

The role of international co-operation

Inter-institutional co-operation should be promoted and strengthened on the model of a network for the exchange of experience, R and D, design and engineering activities, dissemination of information, technical co-operation, and joint R and D projects among developing countries at the regional and subregional levels.

Co-operative R and D projects should be supported for the development of new technologies as well as for improvement of existing ones for operations such as food-grain storage, grain milling, milk processing and preservation, fruit and vegetable preservation, fish preservation, oil-seed processing, industrial utilization of roots and tubers, processing of meat and meat products, and the recyling of wastes and of by-products of the food-processing industry.

The United Nations system and the developed countries could provide assistance to the developing countries by supplying technical information support. More specifically, the developing countries should be assisted in the preparation of inventories of technologies of food-processing industries of particular interest to them.

PART TWO

Selected background papers

Technological choice and employment in food processing and storage and related policy issues

*J. Keddie**

INTRODUCTION

The bulk of the populations of the developing countries–that is, a majority of all people–are poor. They lack the goods and services without which men and woman cannot live in freedom from want. The meeting of these needs, the eradication of poverty, should be the first concern of mankind and the overriding goal of development. - No measure, institution, or practice–technology included–can be called "appropriate", unless its primary aim and effect is to serve the interest of the poor.

In the developed industrial countries, the problem of grinding mass poverty has largely been solved. Following the Second World War, the emergent nations not unnaturally took the progress and techniques of the industrial countries as a model which they had only to copy or "transfer". As the years have passed, however, doubts have arisen even in the industrial world about the long-term wisdom of this model of development. Although it has reduced material poverty, it has left many alienated by its apparent impersonality; and people have begun to wonder whether, in a world in which easily exploitable non-renewable resources are rapidly shrinking, an industrial civilization based on intensive use of energy and metals can long endure.

Modern industry in developing countries is an important component of the attempt to transfer, rapidly and on a large scale, the economic and technological systems of rich countries. Government planners, and all others concerned with development, should consider whether the role and practices of industry should not be radically changed in favour of a model of development that serves the interest of the poor.

The present level of technology in advanced countries has been attained in some cases by centuries of research and development (R and D). Are there suitable alternatives to large-scale "modern" technology available in practice?

It is scarcely surprising that the main thrust of research in developed countries has been towards even more highly processed and packaged products,

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*Monitoring Economist, Scottish Development Agency, Glasgow, Scotland, United Kingdom of Great Britain and Northern Ireland. Mr. Keddie acknowledges the assistance of W. H. Cleghorn and C. Baron of the International Labour Organisation (ILO) in the preparation of this paper.

and the perfection (and particularly the automation) of mechanical processes for their production. But in a developing country, a more typical example of ingenuity may be a homemade device for preservation of fruits and vegetables which might otherwise be available only seasonally. The developing countries are not restricted to slavish imitation and transfer of the present techniques of the industrial world. They can devise solutions to their own problems.

A truly appropriate technology provides two complementary desiderata: products at low cost and purchasing power to buy them. It is a major premise of this paper that in the developing countries purchasing power may only be secured for the poor by the large-scale creation of jobs. The conjunction, if possible, of low costs with employment creation may be expected to produce snowballing dividends, with low costs leading to large markets resulting in substantial industrial employment which further enhances those markets.

In food processing, no account of technological choices can be complete without consideration of the nutritive value of final products. This paper can do no more than touch on the insights provided by a large and complex subject, a specialist discipline in its own right. Fortunately, it is possible to classify most important foods according to basic nutrients–energy-supplying foods (including oils and fats as a special category), proteins, vitamins and minerals. Using this classification, activities reasonably respective of nutritional needs could be selected, and observations made on the costs of certain methods of conducting these activities. Concern for nutrition also suggests the importance of considering grain storage.

Six case studies in food processing

Case studies are given of the choice of appropriate technology in six major food processing activities: rice milling, breadmaking, fruit and vegetable preservation, milk processing, fish preservation and beer brewing. Costs and revenues are calculated at developing country market prices, with alternative "low" and "high" wages reflecting conditions in the poorer and richer developing countries respectively. A discount rate (test rate of return on investment) of 10 per cent is assumed.

Rice milling

Of all the cereals (food grains), the basic foodstuff of humans, rice is the most important in the developing countries. In 1976, it accounted for 320 million of their total cereal output of 607 million tonnes. The next two, wheat and maize, accounted respectively for only 139 and 110 million tonnes. The great bulk of rice is produced in Asia, where developing country production in 1976 was 294 million t out of a total cereal output of 509 million tonnes [1].

Rice milling is an example of massive and apparently uncompensated displacement of the labour of the rural poor by the introduction of mechanization. This process is matched by parallel developments associated with the green revolution, notably the reduction of incomes of rice farmers unable to use new rice varieties, caused by the price declines consequent upon the introduction of these varieties, and the displacement of local labour in harvesting by work-forces of contract labourers.

Small powered rice mills, larger-scale mills and storage units have all come under economic criticism [2]. There is thus a good case for examining a range of milling technologies and of comparing their costs at different scales of output and wage levels. The present comparison can only approximately represent actual circumstances, for the economics are closely linked with harvesting practice, drying, storage, transport and distribution facilities, climate etc., all of which may vary widely.

Paddy, the raw material, is on average 80 per cent of the weight of the harvested rice before threshing. For this analysis it is assumed to be ready for milling. The purpose of rice milling is to remove the outer husk of the grain with minimum damage to the kernel. Hand pounding and hand milling merely separate the husk from the kernel. Power milling also removes the vitamin-rich seed coating (bran) and the germ to produce polished rice, which is far whiter when cooked than rice with the bran intact. The widespread practice of parboiling before milling reduces vitamin losses and toughens the kernel, making it less likely to break during milling. Its survival even after the spread of mechanized milling has doubtless been responsible for the prevention in some areas of mass outbreaks of vitamin-deficiency diseases (e.g. beriberi) when consumption of unpolished hand-pounded rice has given way to a taste for polished rice.

Hand pounding–the most widespread traditional method of milling–is extremely labour-intensive, with productivity rarely exceeding 5 kg per worker-hour.

The traditional small power-driven rice mill is the Engelberg steel-roller type, using a 10–15 hp (7.5–11 kW) engine. They are sometimes used in series, a pair forming a husker-polisher unit. Small one-pass Japanese rubber-roller mills, capable of both husking and polishing the rice, are superseding the Engelberg mill. They offer somewhat higher recovery rates and superior quality.

Larger commercial mills tend to be at central locations, and may incorporate threshers, artificial dryers and bulk- or bagged-storage facilities. The older types use disc shellers and multi-stage roll-stands, but more recent designs utilize large rubber rollers handling up to 2 t/h or more. Large integrated milling and storage plants may handle up to 25 t/h.

Developing country experience with larger mills has not been particularly encouraging. Though they may offer potential economies of scale, much depends on the rate of utilization which can be achieved.

Schedules of outputs and inputs have been summarized for five projects widely varying in scale, each employing a different technology and fairly representing developing country experience. Comparative costs and revenues were analysed.

Largely owing to their low productivity, manual technologies make losses. Among the mechanized technologies, small mills have lower costs and are more profitable than large mills, and the rubber-roller version of the small mill is more profitable than the Engelberg type, because of its higher yields. On the available evidence, small rubber-roller mills are as likely as multi-stage mills to turn out rice of premium quality.

The above comments, however, are only from the point of view of the private entrepreneur who buys equipment, labour, paddy etc. and sells the milled output. The results merely show that manual techniques are not attractive commercial propositions, particularly when wages are relatively high.

But most of the world's rice is consumed in countries with low wage rates, e.g., Bangladesh, India and Indonesia. Results indicate much lower cost premiums at low wages. It is only very large cost premiums that indicate an unshakeable inefficiency, since prices, and thus costs, themselves depend on existing economic conditions, which may well well be inequitable in the first place.

Moreover, even if such inefficiency were assumed and mechanization of rice milling advocated, there would still be a substantial problem in assuring that the implied overall gains to society are shared fairly, particularly with the hand pounders and millers displaced from their employment in the process. At high utilization rates, multi-stage mills require 24 workers to mill 5,760 t of paddy per year, small mechanized mills, 27. A labour force of 1,000 would be required for the hand-pounding of the same amount of paddy. Thus over 99 per cent of the employment loss from mechanization is incurred in moving from hand-pounding to small mills; and since tens of millions of tonnes of paddy are involved, very large numbers of people are affected.

The rural poor have ever sought to supplement inadequate incomes by pounding the rice of their slightly richer neighbours. Unless policies are instituted to give them alternative incomes, not even the small mechanized mills can be termed appropriate in the face of the destitution they cause.

Breadmaking

Bread may be regarded as a luxury product in some poorer developing nations. As a convenience food, neither very cheap nor very expensive, demand will probably increase as incomes rise in developing countries, and it can make a valuable if expensive contribution to a protein-deficient diet [3]. Evidence from Kenya [4] indicates that small-scale widely dispersed baking of raised wheaten bread by labour-intensive methods can flourish in competition with large mechanized bakeries. Thus bread, if not ideal for meeting the nutritional needs of the very poor, may offer them prospects of employment, already realized in the case of traditional unleavened bread.

Although the baking of raised bread has traditionally been mainly manual, most of its stages have potential for mechanization. Information from Kenya on three bread-baking projects, two small, and one much larger and more highly mechanized, was privately communicated to the author by R. Kaplinsky, who emphasized that the largest bakery is exceptionally efficient. In contrast, the wood-fuel consumption in the locally constructed ovens of the two smaller projects may be more than double that of bakeries of similar size and type in some other developing countries, such as Sri Lanka.

Analysis of cost and revenues of three projects shows the mechanized bakery to be most profitable. This may be partly due to marketing differences, for a luxury wrapper is used, and the loaves sold half wholesale, half directly delivered to the retailer. From the small projects it is all sold wholesale in plain wrappers, circumstances assumed for the large project also. At high wages, neither small project makes a profit. However, the difference in profitability between small and large projects is marginal at low wages, and would remain so under an intermediate wage régime.

Thus, only in the highest-wage developing countries can the manual process be said to have inappropriately high costs compared to even well-managed large mechanized bakeries. At low or intermediate wage levels, they are to be recommended for the extra employment they bring. For every million tonnes of flour used, the manual bakeries would provide 73,000 non-management jobs as opposed to 13,000 provided by the mechanized process. This might be considered an adequate way of sharing with the poor the benefits of producing a rather high-cost form of basic nutrition.

The extra employment could moreover be widely dispersed in rural areas. Kaplinsky found many small bakeries in the Kenyan countryside.

A final qualification, however, is that the manual process, with its wood-fired ovens, consumes–at least in Kenya–about 632,000 tonnes of coal equivalent (tce) per million tonnes of flour, the mechanized only about 121,000 tce [5].

Gross energy figures do not tell the whole story. To use a cheap and renewable energy source may be better in the long run than to use lesser quantities from limited and increasingly expensive sources. But until firewood use is properly controlled and sustained by afforestation programmes in the developing world, the massive consumption should not be lightly encouraged. An immediate priority is therefore to ensure that ovens are of reasonable thermal efficiency. Any improvements in oven design, bringing fuel economies at low investment, can be recommended for R and D projects.

Fruit and vegetable preservation

Fruit and vegetables are second only to cereals in terms of tonnage produced in the developing countries, and are extremely varied. Their particular problem is rapid perishability. A joint FAO/UNICEF/WHO committee said in 1976, "large seasonal shortages in food distribution could have disastrous effects, particularly for children" [6]. The preservation of perishable fruits and vegetables must therefore rank high in any list of priorities for food processing.

The perishability of fruit and vegetables is caused by the action of enzymes and micro-organisms in the presence of air and the high internal moisture content of these foodstuffs. The oldest method of preserving them is by drying. The next oldest is to sterilize them by heat and seal them in airtight containers, usually tin cans. The third principal method is to keep the product frozen until it is to be eaten. This more closely preserves the original texture and taste than does drying but unfortunately entails high capital costs and the need for careful control.

Other methods exist, notably preserving in sugared form and irradiation. The former, usually limited to fruit, requires relatively high capital costs and excellent raw-material quality [7]. Irradiation kills the micro-organisms, after which the product is packed or stored under controlled conditions. Although carefully investigated, this method must be regarded as being still in the testing stage, though it may have an attractive potential [8]. Yet another method, freeze-drying, is extremely costly and limited to high-value products, even in developed countries.

In canning, the degree of mechanization is usually associated with the speed of the line. Small-scale operations are by hand, whereas high-speed canning lines use machines. Small-scale canning also has the advantage of permitting the use of an exhaust box, which evacuates the air from the unfilled space at the top of the can after filling and just prior to sealing. This ensures that no air is sealed inside the can. In higher speed lines, steam is injected into the unfilled space, a method said to lead to a shorter shelf life. "With these high-speed lines, people seem to have got away from the original idea of canning, which was preservation: it's become a container" (private communication from a major can and canning machinery manufacturer). Other important stages are cooling and drying. Before cooling, the seam may not be completely watertight. The can must be cooled quickly and the cooling water used must be chlorinated or pure. After these stages, the can has become both watertight and airtight, and shelf lives of several months may be expected.

Drying techniques vary. Drying in the sun does not produce uniformly reliable results, althought it is sometimes perfectly satisfactory, as with raisins. A considerable technical improvement, at minimal cost, is the simple solar dryer. A small area is walled off with mud-brick walls about 70 cm high, and prepared vegetables are placed inside on trays. The whole is then covered with two separated layers of transparent polythene stretched over a wooden frame. This device increases air temperature inside the walls up to 60–70°C in hot sun, cuts drying times to as little as three hours, reduces vitamin loss, and kills off many of the micro-organisms [9]. For storage, thin-walled cement jars may also be cheaply made on a small scale.

A simple artificial dryer fired by wood or crop wastes may also be used. A shed is erected over the drying area to keep off rain, and oil drums may be used as fireboxes. Products may be stored as before in cement jars, or sealed in smaller lots in plastic bags.

Larger-scale methods are sophisticated, controlled, and mechanized variants of the simple artificial dryer. Two analysed here employ steam scalding prior to drying and even out the temperature and moisture content of the dried product in conditioners. The product is packed mechanically in plastic bags which seal out moisture. Lower-speed lines use trays moved progressively by hand from upper to lower levels of drying racks. High-speed lines use moving steel belts, the drying products cascading from one level to the next [10]. Both aim to control the drying into defined stages corresponding to the degree and location of the moisture still in the product.

Industrial freezing is usually done on a large scale. One method has a mechanized preparation and packaging line, followed by bed-freezing and a refrigerated store [11]. Many links of refrigeration in transport, warehouses, retail cold stores and freezers, and perhaps in domestic refrigerators make freezing eminently susceptible to failure and almost certainly too expensive for supplying food to the poor.

No preservation method is perfect. The essential technical requirement of keeping products palatable with reasonable nutrient preservation for several months is met by all the methods described, provided normal care is taken.

Summary schedules of inputs and outputs for eight vegetable preservation projects applying different technologies at varying scales of operation were based mainly on data privately communicated. Attempts were made to adjust operating coefficients to reflect developing country conditions, in particular by assuming lower labour productivities, and to check adjusted coefficients against observed developing country productivity in other industries with similar operations. Required manning levels may have, however, been understated for the freezing and continuous belt-drying projects and overstated for the modern tray-dryer.

Processing costs were estimated on the basis of the schedules. Of the three main methods, drying is evidently the cheapest and canning the dearest, with freezing occupying an intermediate position. The direct comparison of in-plant processing costs is, however, unduly favourable to freezing, because subsequent costs are obviously high. Apart from transport it has been estimated that every day the frozen product remains in the shop or home adds $9 per tonne to preservation costs. Frozen foods are cheaper than canned, but only to those who can afford to eat substantial quantities of them. On the other hand, the costs of canning are vastly greater than those of drying, largely due to the costs of cans ($305 per tonne of input).

There are no marked economies of scale in canning, and the very small solar dryer has the lowest costs of all. Drying must be judged the appropriate technique. Different employment opportunities are not sufficiently large to affect the balance of judgement. Employment per million tonnes of input ranges from 5,926 jobs for continuous belt drying, to 12,500 for solar drying, 23,210 for small-scale canning, and up to 33,333 for modern tray drying. As regards energy consumption, although there is a case for attempting to improve the thermal efficiency of wood-fired dryers where climate does not permit use of the solar dryer, there are no grounds for supporting canning as an energy-saving technique, the energy content of cans being extremely large.

While vitamin retention is not at its highest in drying, it is adequate; large canning or freezing projects may have to face vitamin losses before the raw product reaches them.

Further low-cost technical improvements may include packing products from small-scale dryers in plastic bags sealed with a simple heated tool.

Milk processing

Given the diversity of milk products, some concentration on a limited range is essential. Attention is accordingly mainly focused on the technology and costs of pasteurization and buttermaking.

A typical process for pasteurizing and packing whole milk may give the additional possibility of using some of the pasteurized milk to make butter and skim milk to be sold liquid or dry. Dry milk may be held in cold storage until it is reconstituted and packed. Process details vary. Homogenization, achieved by forcing the milk through tiny holes which break up the butterfat globules is optional, as is the pasteurization and salting of butter. The steam-heated drum-dryer is probably the simplest method of drying skim milk; and pasteurizing by steam, hot water heating or infra-red radiation. (Sterilization, which allows storage of milk for long periods, is a different procedure which exposes the raw milk to temperatures of about 130°C.) Plastic bags are the cheapest containers unless very good recovery rates can be achieved for glass bottles. Perhaps of greater significance are the conditions under which dairies must operate. Efficient raw-material delivery and packed product dispatch are vital, since both raw and pasteurized milk spoil rapidly at high ambient temperatures. Developing country dairies are often grossly underutilized for lack of adequate supplies [12, 13].

Schedules were made of inputs and outputs in four milk-processing projects of widely varying scale. At the largest scale two variants were considered. The first uses a fifth of its milk input in making butter and skim milk; the latter then is dried, stored, later reconstituted and sold in liquid form. The second variant, like the two smaller projects, pasteurizes and packs all its milk. The schedules are largely based on data provided by Swiss and French dairies and equipment manufacturers; use was also made of UNIDO profiles of dairies in developing countries [14].

Technology in the large and medium projects is standard, but the small project uses integrated French equipment designed for largely manual operation by a handful of people. The small project has a further interesting feature, pasteurization by direct infra-red radiation. This obviates the need for a steam-raising boiler, but on the other hand increases reliance on electricity, which may be unreliable or unavailable in more remote areas of developing countries.

Costing for the projects assume a milk input price of $0.20 (20 cents) per litre, based on Indian price levels, and a 25 per cent mark-up for pasteurized milk, to determine whether plants can be profitable without raising the price of a basic foodstuff too high. The indications are that they cannot. All the projects make losses, particularly heavy at high wages. Nor is the incorporation of butter and skim milk production into large projects profitable. The combined revenue from butter and skim milk is actually less than would be obtained by simply pasteurizing and selling the whole milk. Even if pasteurization alone is considered, large projects have no impressive advantages over small ones. The processing costs per litre of pasteurized milk (covering 10 per cent real return on investment) at the three project scales are given in table 1.

At low wages in particular, the small project compares quite well on costs with the large one, with the medium-scale plant emerging as a high-cost alternative. It is possible moreover that the costs of the small project have been overstated and those of the large one understated. Labour productivity for the small project has been assumed at less than half French levels; and at such a small scale an economy in energy costs could probably be effected (if with some increase in investment costs) by the incorporation of a diesel electric generator, which would have the additional advantage of releasing the plant from dependence on restricted and unreliable mains supplies. On the other hand, the labour productivity assumed in the large project, while considerably below

TABLE 1. PROCESSING COSTS IN TERMS OF WAGES PER LITRE OF PASTEURIZED MILK

Scale of project	Wages (cents)* Low	High
Small	6.5	9.0
Medium	8.3	11.0
Large	6.0	7.5

Note. Costs cover 10 per cent of real return on investment.

*1 cent = $0.01.

European levels, is much higher than that indicated by the UNIDO profiles, which also suggest a somewhat higher machinery investment cost.

It is probable that the very scale of the large project is its most important disadvantage with problems of finding sufficient milk and organizing uninterrupted collection and transport. In some developing countries, unless very careful attention is paid to supply and pricing, the most likely result of establishing a large dairy project is massive underutilization. To cover ensuing high processing costs, management may attempt to pay the milk producers low prices while charging high prices for its output. The public may then buy raw milk direct, thus worsening the supply problem. Precisely this cycle was diagnosed in Somalia by the International Labour Organisation (ILO) in 1976.

It seems that for pasteurization in the developing countries, small projects are most appropriate. Besides basically competitive costs, they may provide slightly more jobs (about 9,600 non-management jobs per million tonnes of raw milk input per annum, compared with about 6,800 for large projects) and consume considerably less energy (76,000 tce per million tonnes raw milk, compared with 136,100 tce for large projects), at the cost of higher requirements for fixed assets ($124 million compared with $89 million). They have of course the additional advantage of possible dispersal into rural areas. Diesel electric generators would further increase fixed asset requirements, but mains supplies also carry fixed investments, even though these are not within the dairy industry.

There must, however, be some doubt as to whether an extensive milk-processing industry, whatever its technology, is appropriate in many developing countries, where milk and milk products are relative luxuries. There is evidence that they are consumed largely by upper income groups. Calculations show that milk is expensive, whether considered as a source of energy, fat or even protein.

Mass consumption of milk cannot be recommended as a cheap source of nutrients. Where the keeping of milk cattle has little cost, or is sanctioned by religion, milk is of course to be welcomed as a supplement in rural nutrition. But deliberate encouragement of commercial milk production should be recognized for what it is: an encouragement of luxury consumption of a costly source of nutrients. The mass pasteurization of milk might perhaps be advocated and subsidized on medical grounds. However, even a massive subsidy would bring no benefits to a large proportion of the very poor, and the health budgets of most developing countries are rather meagre.

Fish preservation

Fish provides less than 0.2 per cent of world food-energy requirements, but accounts for about 20 per cent of animal protein in the human diet [15]. The world catch in 1975 was 70 million tonnes, no greater than in 1970, though the quantity for human consumption rose during the interval by 11 per cent to 49 million tonnes. A further 6 million tonnes are caught annually by subsistence fishermen, according to FAO estimates in 1975 [16].

More than nine tenths of the total catch came from salt water. Thus, in the absence of preservation, access to this important protein source is restricted in inland areas of developing countries. Much fish is in fact preserved: in 1975, 8.1 million tonnes were smoked, dried or salted and 7.2 million tonnes were canned, according to FAO statistics.

Fish canning in developing countries may be almost exclusively for export to the developed countries, on the model of the Moroccan export industry. Several Latin American countries, however, can large quantities without a correspondingly large export trade. A study of basic needs in Swaziland listed tinned pilchards among items of a minimum daily diet [17].

It is therefore worthwhile considering whether canning fish for domestic consumption may become widespread in developing countries, and to compare its appropriateness with fish curing, a technically simple set of processes including drying, salting and smoking. Both are technically able to conserve fish for consumption in inland areas. The comparison is given added point by increased productivity of traditional coastal fishing following the adoption of small outboard motors and tough synthetic-fibre nets [18].

In traditional smoke drying, the fresh fish is placed above a wood fire, where it dries and cooks, acquiring a smoky flavour. Simple design improvements at low cost have been shown to increase yields and quality. Tropical fish may be uniformly smoke-dried in simple wood-fired brick cabinets and stored in sheds over a period of approximately 15 hours. Batch sizes range up to almost 300 kg, and the final weight of the dried product is about one third of the fresh weight.

Fish may be canned on a very small scale, but the typical cannery in developing countries, as elsewhere, is a large-scale mechanized enterprise with a high investment cost and a high rate of daily utilization, but often working only for a limited season. The catch may be pumped directly from the holds of large fishing vessels, after which the process differs only in detail (for example, the fish is cooked before the can is sealed) from that of fruit and vegetables.

Summary schedules of three projects, two smoke-drying on a small scale, and the third a large cannery, were based, for smoke drying, on the FAO study of improved smoke-drying techniques; for canning, on the same United Kingdom sources used for fruit and vegetable canning, checked against a United

States Agency for International Development profile of a sardine cannery [19]; and, for manning levels, on a study of developing country breweries by the author and W. H. Cleghorn [20].

In the cannery, 1 kg of small fresh fish is assumed to be converted into a net can content of 1 kg, of which 0.85 kg is the edible portion, 0.12 kg is edible oil, and 0.03 kg is salt. In smoke drying, 1 kg of fresh fish is converted into 0.33 kg of dried product. One kilogram of net can contents is thus equivalent to 0.85 kg, and 1 kg of dried fish is equivalent to 2.40 (3 × 0.80) kg, of edible fresh weight.

On a comparative cost and revenue analysis, small-scale drying is much cheaper than canning, with the slightly larger project being lower cost and more profitable than the single-oven variant. Canning is even more (about four times per tonne of edible fresh fish weight) profitable because of the high price of canned fish. If cost prices per tonne are calculated for the cannery and the larger smoke-drying project at low fresh fish prices, with the costs of edible oil and salt excluded from the cannery costs, the pattern shown in table 2 is found.

TABLE 2. COMPARATIVE WAGE COSTS OF PRESERVING FISH (DOLLARS PER TONNE OF PRESERVED FISH)

	Smoke drying		
Wage level	*Single-oven*	*Larger scale*	*Canning*
Low	286	269	677
High	342	290	689

These may be compared with the price per tonne of edible fresh fish inputs, which cost $218 for the smoke-drying projects and $205 for the cannery. The processing costs of canning are clearly much greater than those of drying; as with fruit and vegetable preservation, the cost of cans alone ($353 per tonne of edible fresh fish) accounts for much of the differential.

There can be little doubt that smoke drying is the appropriate technique for distant inland markets. Where preservation for later local consumption is concerned, the solar dryer would almost certainly be appropriate. It is not known whether fish so dried would be preserved over long journeys in boxes. Although efforts to increase thermal efficiency of wood-fired drying are to be welcomed, canning is a much more energy-intensive technique, again because of the energy content of cans. Smoke drying also provides greater employment opportunities, requiring, per million tonnes of edible fresh fish input, 46,300 non-management workers for smaller-scale projects and 23,100 for larger projects; canneries require 9,000. Smoke drying also has lower investment costs and the savings might be used to create jobs elsewhere.

With all these advantages smoke drying is to be strongly preferred over canning. Even where conditions permit large-scale fisheries with geographically concentrated landings, the catch may be processed by a cluster of small smoke-drying enterprises rather than by a large cannery.

Beer brewing

European-style brewing is a substantial food processing industry in developing countries, apart from the stricter Moslem nations, although consumption *per capita* is much lower than in developed countries. In 1974, the developing countries brewed about 100 million hectolitres of beer. This requires an input of about 1.8 million tonnes of grain, mostly malted barley, which usually entails a considerable import bill in hard currencies. The 1974 ex-brewery value of European-style beer production in the developing market economies has been estimated at $4,500,000 and probably provides an almost equal sum as government revenue. Moreover, the typical brewery is a large modern production unit using several million dollars of almost exclusively imported equipment. Such breweries are usually found in the large cities, where they often pay higher wages than other large modern plants. An estimated annual increase of output was 8.3 per cent between 1963 and 1972 in the developing market economies. European-style beers, predominantly lager, are based on malted barley (malt) and bittered with hops. The term "beer" may, however, be used to cover all fermented drinks based on food grains, and there are in the developing world many traditional beers brewed from local grain, notably sorghum, millet and maize. These are often made on a very small scale, although large-scale commercial production is practised in southern Africa [21]. Lager is a clear, sparkling drink from which great care has been taken to remove even the protein content of the original malt. In contrast, traditional processes leave the whole nutrient content of the grain in the beer, often including even the grain husks, which in lager brewing are filtered out and sold to local farmers as animal feed. The principal disadvantage of the traditional beers is their short shelf life. Unlike lager, they are sold (and consumed) while still fermenting, and must be drunk within a few hours or days of sale, before the uncontrolled fermentation produces an unacceptable taste.

European-style lager brewing is a lengthy and complicated process. The malt and adjunct foodgrains (typically processed maize) are milled and mixed with hot water to convert the grain starch into sugars. The grain husks are then filtered off, and the filtrate boiled with hops, which gives the beer its bitter flavour. The resulting wort is again filtered, cooled, and collected in vessels, to which yeast is added to convert the sugars into alcohol. After this fermentation stage, the beer is transferred to other vessels for conditioning in cold storage; this removes the residual protein along with harsh flavours. It is then carbonated, and filtered again before it is ready for bottling, the normal packaging process in developing countries.

The brewery requires steam for boiling the wort and pasteurizing bottled beer; refrigeration for cooling the wort and maintaining low temperatures during fermentation and conditioning; and electricity, engineering maintenance and a laboratory to provide precise process and quality controls.

Considerable technical expertise is needed. Nevertheless, there is a wide range of technical choice, e.g. fork-lift trucks or manual handling of materials and bottles; pure malt, or a mixture with maize "grits" as brewing materials; vessels of stainless steel or cheaper materials; the conditioning period may be long or short; wooden crates or cardboard cartons may be used as bottle containers; and many bottling operations may be either mechanized or manual.

The production of traditional beers permits many simplifications, such as simpler wort production; a smaller and less refrigerated set of fermentation and conditioning vessels; the omission of pasteurization and packaging, the beer being delivered in tanker trucks; and a lessening of product susceptibility to the development of unacceptable flavour and aroma as a result of minor changes in raw materials or processing.

Seven brewery projects with three scales of output were selected for comparison. The largest is large by the standards of most developing countries, the medium scale is perhaps more typical. The small scale, still a substantial industrial enterprise, is reserved in this analysis for the production of corn beer, a variant of traditional beer brewed in East Africa from millet and maize.

At both the smaller scales, production is assumed to double after four years, while the largest-scale projects work at full production from the start. At full production, all work at high utilization rates, but for the small project a more relaxed schedule is assumed.

At each of the larger scales, three lager-brewing technologies are considered. Turnkey technology is typical of many mechanized breweries recently erected. Least-cost technology represents the narrow range previously found to be least-cost at the scales considered. Low-cost job-creation technology parallels least-cost technology except in bottling operations, where considerable substitution of labour for equipment is assumed. At the small scale, the single corn beer technology is based on an amalgam of an industrial project observed in East Africa, and the tanker truck delivery system practised in southern Africa.

Summary schedules of inputs and outputs were based on a study by the author and W. H. Cleghorn, which in turn was based on direct observations in developing countries.

Cost and revenue analyses of the seven projects show brewing to be highly profitable at either low or high wages, lager tending to be more so than corn beer. At the medium scale, least-cost lager technology shows a net present value (NPV) of $16,114,000 at low wages, almost five times that of the corresponding NPV of the corn beer project, which operates at one quarter the scale; and the larger projects are more profitable still. However the turnkey project can be less profitable than the corn beer project, especially at high wages.

The comparative profitability of lager rests on extremely high prices. When excise taxation and trade margins are allowed for, the ex-brewery price retail is approximately 80 to 90 cents per bottle of 660 ml. At developing country wage levels, lager beer is clearly a "luxury" product. Even at its least costly, in large projects using least-cost technology at low wages, the ex-brewery cost of $25.9 per hectolitre, may be compared with $12.6 for corn beer, also at low wages. Since a hectolitre of either type is based on about 18 kg of food grains, the minimum processed costs per tonne are $1,440 for lager and $700 for corn beer, before taxes or trade margins. Moreover, in lager brewing much of the nutrient content of the grain is removed.

Although beer is not usually consumed for nutritional reasons, it is arguable, firstly, that a cheaper variant should be promoted to satisfy the demand for intoxicants, and secondly that if large-scale production of such a luxury is to be tolerated it should be only on the basis of some equitable sharing of the benefits with the poor. Low-cost job-creation technology, by generating employment in the large-scale bottling operations of lager breweries, is one means of achieving this objective. It adds 1,800–1,900 jobs per million hectolitres in bottled form, and the cost premium is small at low wages.

Corn beer seems a more appropriate product than lager in many developing countries. Care should be taken, however, in its production on an industrial scale, since this is a substantial household industry. In several African countries, production on a very small scale may provide the principal means of support for single women. Industrial-scale production might reduce them to destitution. If corn beer is to be encouraged on an industrial scale, it should be aimed at reducing the consumption of lager, on which prohibitive excise taxes might also be levied.

Present lager breweries produce a luxury product, typically contribute little to local agricultural employment, provide few jobs (all in towns), and consume large amounts of foreign exchange and investible funds. But similar inappropriate features of transferred modern technology have been evident in the other studies presented in this section.

Food-grain storage

Although storage losses of grain can be exaggerated, appropriate grain storage technology may be very important in meeting the basic needs of the poor, through an increase in their incomes, a reduction in the costs of the most basic of all foodstuffs, and the provision of employment opportunities. However, the importance of these factors varies with the level considered: farm or village local storage, or larger-scale urban or national storage.

In India, 60 to 70 per cent of the stock of food grain is estimated to be kept in local storage by farmers or local merchants [22]. The proportion is probably similar in many other developing countries. Most is stored in structures made very cheaply from local stone, clay, bamboo, straw, and the like. Loss rates are not very high, yet may be reduced by low-cost improvements in design, providing better protection against pests and moisture. In Zambia, an improved method involves shelling maize kernels from the cob and storing them in a crib plastered with dried mud inside and out. Both there and in India, such improvements have shown favourable benefit-cost ratios.

It seems likely that village-level storage improvements are worth persevering with, particularly where, as in India, employment is generated. Such a pattern seems possible in densely populated societies where specialization of labour has a long tradition. Another possible advantage may be to help small-holders keep their produce at harvest time rather than selling it to a trader or money-lender and perhaps buying it back later at a higher price. It would also benefit consumers by reducing concentration of grain supplies, thus discouraging monopoly profiteering.

The choice of technology at the urban level is basically between silos of steel or concrete and warehouse storage in bags (bagged storage). Silos are better adapted to the grading and storage of a few varieties of grain in an environment in which moisture and temperature can be precisely controlled, but bagged storage is also capable of minimizing losses with careful management.

Summary schedules of input requirements for the two techniques at two commercial scales are largely based on the previously cited study of breweries. In the matter of investment costs for silos, however, other sources were used [23, 24, 25]. From these it was not possible to detect economies of scale in silo construction. Nor could different costs be attributed with certainty to concrete silos, which seemed from some of the evidence available to be the more expensive.

The scale of storage facilities is intimately connected, via transport costs, with particular circumstances of grain surplus and deficit areas. A more significant result energing from cost analysis is the much lower cost of bagged storage at both scales and both wage levels. Silos, with their more precisely controlled environment, might have a small advantage in the matter of losses, but losses with bags would have to be around 9 to 10 per cent greater than with silos for the costs of the two to be equalized at low wages. Such differential losses appear quite incredible.

Bagged storage provides other benefits. Silos are likely to be large-scale, permitting both exercise of monopoly power and ready grading of the grain to secure high prices. Large-scale silos are often mis-sited and therefore underutilized, further raising their costs. Bagged storage also provides more direct employment: 2,060 jobs more per million tonnes of annual grain throughput at the smaller scale, and 2,800 more at the larger. It also effects considerable investment savings of the order of $100–$150 million per million tonnes throughput. Moreover, in some developing countries about 60 per cent or more of silo investment goes on foreign exchange. With all these advantages, bagged storage must be considered the appropriate technique for urban grain storage.

CONCLUSIONS

Summary of results

The foregoing sections have demonstrated that alternatives to large-scale modern technologies exist, that it is possible to evaluate such alternatives and that in these comparisons it is frequently the alternative technologies that emerge as more appropriate [26, 27]. However, they cannot be typified, nor is a uniform set of advantages apparent in each. Determination of appropriateness usually requires a judgement of the advantages crucial in a particular activity. The advantages offered by the appropriate technologies therefore vary from one food-processing activity to another.

In rice milling, small powered mills are cheaper than either large mills or manual techniques, and the rubber roller variant attains the highest profits of any. The results are disturbing, because the labour-intensity of the small powered mills is hardly any greater than that of their large counterparts; thus their supersession of manual techniques poses great problems of unemployment or diminished income among the rural poor in major rice-producing countries.

Manual techniques must continue to be judged appropriate in the major Asian rice economies unless and until a method is found of compensating those displaced by the introduction of the small powered mills.

Well managed, large mechanized bread bakeries offer higher profits and lower costs than smaller labour-intensive bakeries. However, the latter are competitive with the normal run of large mechanized bakeries, and offer significant employment opportunities, which may provide a means of sharing with the poor the benefits of producing what is a semi-luxury product for many developing countries. Small bakeries are therefore more appropriate. However, they are relatively energy-intensive, and R and D to reduce fuel consumption at low investment cost should be accorded a high priority.

Of the three major methods of fruit and vegetable preservation, drying is found to have the lowest costs. Canning is a very high cost technique, largely owing to the cost of the cans themselves, while freezing must bear the costs and uncertainties of a long cold chain up to the point of consumption. Drying is thus the appropriate technique. It is its low costs that makes it attractive, for it is not particularly labour-intensive, and nutrient retention, though acceptable, poses some difficulties. Where climate does permit direct reliance on simple solar dryers, attention might profitably be paid to improving fuel economy in small wood-fired dryers.

In milk processing, small-scale plants are slightly more labour-intensive and consume less energy than large plants and compare well with larger plants in processing costs. However, processing entails substantial investment, whatever the technique, and it is doubtful whether an expansion of commercial milk production should be encouraged. Milk and milk products are expensive sources of energy, fats and protein, and are luxuries in many developing countries.

Fish drying is a much cheaper preservation technique than canning, and in small plants with simple equipment considerably more labour-intensive than large canneries. Such plants therefore represent the appropriate techniques.

In beer brewing, at least two options are available. It may be appropriate to promote cheaper beers based on materials supplied by local agriculture. Alternatively, the potential of lager brewing for generating significant direct employment might be fully exploited as an appropriate way of providing the poor with some benefit from the production of a high-income product.

Extraordinary supply increases cannot be expected to arise from improved food grain storage. Low-cost technical improvements using local materials and labour are appropriate investments at village level. Besides increasing food supplies, such improvements may provide construction employment and increase the incomes of small farmers who can afford to invest in them. They would probably also involve bagged storage in warehouses, which is considerably cheaper than the appropriate urban or national practice of silo storage, reduces investment and foreign exchange costs and slightly increases direct employment opportunities.

In rice milling, breadmaking, fish preservation and lager brewing the appropriate techniques are labour-intensive, and offer significant opportunities for maintenance or generation of employment. Low cost is the principal characteristic and advantage of appropriate techniques in fruit and vegetable and fish preservation, food-grain storage, and in beer brewing. They offer cheaper supplies to the poor, but with no guarantee of great direct employment generation. However, given good planning, and political will, their low costs could enable them to capture large markets, the low investment would permit their rapid expansion while still leaving potential for complementary investments in agriculture, and agriculture and industry could together provide increased employment.

Prospects for the future

The potential advantages of alternative technologies should not induce a blindness to practical difficulties. It is sobering to reflect that none of the appropriate technologies can be said unequivocally to be the most profitable and that present conditions are perhaps conducive to the rapid spread of only one of them, small labour-intensive bakeries.

On the other hand, all of the appropriate techniques are already in place in the developing countries, whence came most of the data used to calculate their cost. They are still susceptible to improvement, particularly through reductions in energy consumption. However, what is now primarily needed is wider application rather than technical improvements–extensive rather than intensive development. The two methods are not contradictory, for intensive development will often aid the spread of the improved technique. The distinction is made to highlight priorities, and also to emphasize that technical change is not the only method of implementing the expansion of appropriate technology.

A strategy for implementation embraces, firstly, the controls needed to create a favourable environment and, secondly, promotional measures designed to encourage widespread application. Controls would discourage the flow of funds and skills into inappropriate technologies. Among them might be high tariffs on imported machinery and frozen prices for high-cost products. What is needed is a change in the path of development such that its further benefits go as a first priority to those whose basic needs are not yet met. Promotional measures for appropriate techniques might include a widespread loan programme to small food-processing units and local equipment suppliers, and concessional rebates on raw materials purchased.

There is a strong case for the establishment in finance, industry or planning ministries of technology search and appraisal units to keep up to date with imported and domestic technologies in the more important industries. They might also advise on appropriate tariffs for machinery and raw materials and search for previously neglected appropriate technologies that can be promoted. Technical R and D is also welcome, though in all intensive developments the aim should be the preservation or expansion of the employment and incomes of the poor, rather than the encouragement of small-scale units *per se*, since some of these–for example, small powered rice mills–can reduce employment just as much as their larger counterparts.

However useful appropriate intensive development may be, it will not normally obviate the need for promoting the rapid spread of existing appropriate techniques. Promotion may be effected most usefully by an expansion of craft training. The widening of agricultural extension services may be most fruitful.

Where production for marketing means an investment of a few thousand dollars and the employment of more than a handful of people, training programmes for potential artisans and small businesses are indicated, backed by loans to successful trainees for the purpose of setting up small enterprises.

Finally, supporting action at the international level should not be neglected.

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Food storage and processing

*J. E. Cecil**

INTRODUCTION

From the moment food is harvested, until it is eaten, the best handling techniques that can possibly be applied ought to be used. The importance of this–to ensure that as much as possible of the original value of the crop reaches the consumer–cannot be too strongly emphasized. To preserve as much as possible of the original values, for as long as possible, is therefore the objective of storing and processing systems.

In the broadest sense, we are governed by social and religious habits directly and indirectly in what we eat. Physically, we need food because it is a source of energy, amino-acids, vitamins, minerals, non-metabolizable fibre and other essentials. Food must be wholesome. It should also be attractive. Sensual aspects, particularly taste, are frequently overriding criteria for selecting the way of presenting food–sometimes even to the detriment of nutritive values. This can be illustrated by the preference of many British people for overcooked green vegetables; excessive cooking reduces the level of vitamin C. Another example is the resistance of consumers in many countries to parboiled rice; parboiling before husking improves the nutritive value–particularly the content of the B vitamins–but the resulting appearance, taste and texture make the rice unacceptable among certain groups.

Taste also influences the choice between variations of essentially the same food. Where cost is not important, *gur* (raw lump sugar), a technically less advanced form of sugar than white or brown sugar, is sometimes used in preference to refined white sugar because of its flavour. Conversely, the flavour is sometimes tolerated in the unsubstantiated belief that the coloured product is nutritionally of greater value.

The need therefore is to retain as many as possible of these unrelated tangible and intangible qualities of the original food. An ideal system would retain all of them indefinitely, but with a few exceptions such ideal systems are not practical. The food technologist is therefore faced with a choice between various imperfect systems; and has to make the choice depending on the qualities which most need to be retained, and the available resources.

Most existing food storage and distribution systems are undoubtedly capable of improvement. Unfortunately there are usually constraints on the

*Section Head, Industrial Development Department, Tropical Products Institute, London, United Kingdom of Great Britain and Northern Ireland.

adoption of a better system. Perhaps the most common constraint, though by no means the only one, is cost. Possibly the best approach to storage-systems which involve cryogenics–has limited application in the developing world for local consumption because of the high cost, and for export because of the lack of reliable distribution chains. Warm and humid ambient conditions, the abounding fauna and micro-flora which these favour, and the limited resources available, together present problems of preservation far more difficult than those usually encountered in temperate climates.

Most natural foodstuffs fall into one of a few broad categories of foods, such as cereals, legumes, oil-seeds, animal protein, root crops, fruits and leaf vegetables. Most natural foodstuffs meet human dietary needs in more than one respect. Cereals, legumes, oil-seeds and root crops are important sources of energy, but they also provide amino-acids required for body-building and maintenance–and these substances are present in more balanced and concentrated form in animal protein. Fruits and leaf vegetables are important for vitamins and minerals. There are a few foods that meet only one dietary need–sugar and starches are examples–and even these have potential benefits in other areas of dietary need, for example they have a protein-sparing action when protein is being metabolized to provide energy.

Methods of preservation

In the natural state, most foods can be kept for considerably longer periods if they are in good condition than if they are overripe or damaged. This is particularly important in high-moisture foods stored at ambient conditions in warm climates. Low moisture levels reduce the rate of growth of micro-organisms, and inhibit germination and some enzymatic mechanisms. Cereals, the major food crops of the world, are usually low in moisture when harvested and require minimal processing before storage–indeed, in many instances, nothing more than threshing is required. Grain and sun-dried fruits still possessing some nutritive value after thousands of years, have been found in ancient Egyptian tombs. Low temperatures reduce the rate of degradation of foods of high moisture content; in northern Europe in mediaeval times meat was routinely stored throughout the winter. In acidic conditions pathogens generally cannot thrive. This affords some protection to the consumer when eating fruit products that are normally acidic. A reduced level of oxygen also helps protect food in storage. At reduced oxygen levels, higher forms of animal life, such as insects and mammals, cannot survive. Some biochemical degradation mechanisms are also inhibited.

Processing often merely accentuates the natural methods of increasing storage life. Drying and freezing are obvious extensions–at very low moisture levels even enzymatic hydrolysis of sugar, starches, proteins and fats is inhibited and viable micro-organisms become dormant; at subzero temperatures degradation reactions are very slow. Mechanical removal of oxygen can be made far more efficient, thus eliminating oxidation reactions, which can destroy vitamins and produce rancidity in oils, or stopping the growth of aerobic micro-organisms. Unfortunately, in anaerobic conditions there is an attendant hazard, as anaerobic bacteria can flourish under certain conditions. The most dangerous of these produces a virulent toxin, the effect of which is known as botulism. Processing sometimes involves adding materials which mimic the effects of drying or natural acidity: addition of sugar or salt lowers the water activity, as in jams or salted fish, and additional development of acid provides protection against pathogenic organisms, as in pickles. Isolation of one or more constituents is sometimes necessary before moisture removal (as in the starch, sugar and palm-oil industries) or as an intermediate process between drying stages (the copra industry). Packaging, whether in cans, sacks, paper or plastic, is to protect food from external agencies such as oxygen, moisture, light, micro-flora or animals.

The method selected to process food will depend on a number of factors, including the quantity of raw material available and the market requirements, but most of all on the technological resources available to set up and operate the system. There is a range of technologies that may be used, generally classified as follows: traditional techniques, traditional technology improved indigenously, traditional technology improved by imported techniques, and new technologies.

Imported technologies have the disadvantage that they may not be immediately acceptable for some reason and may have to be modified, if indeed they can be used at all. On the other hand, imported techniques are often based on a much broader background of expertise and knowledge than is available locally and are therefore likely to have potential advantages over indigenous techniques.

The Indian *khandsari* sugar industry provides examples of all these categories. The basic process of boiling sugar juice in open pans is a traditional technique. The adaptation of the sulfitation method to small-scale operation is, it is believed, an indigenous development. The use of roller mills and centrifugals is the result of imported techniques. The amalgamation of all these improvements with the basic traditional technique undoubtedly amounts to a new technology.

Naturally the technique that will be effectively and efficiently adopted is the best to introduce. The Tropical Products Institute (TPI) has proposed the term "optimal" to describe the best from a range of appropriate technologies, accepting that in different circumstances, this could be anything from an expensive, large-scale sophisticated technology to the use of a simple and what may appear to be a rudimentary tool. An appropriate technology is not necessarily the best. Intermediate technology is meaningless without further qualification with respect to cost, scale etc., and the term alternative implies only a difference.

Demands of different markets

Unfortunately, yet another consideration must be discussed: the market for which the food is being prepared. Two basic food handling situations may be distinguished. One, regulated to a greater or lesser degree by internal government authorities, is concerned with the feeding of local populations. The other, often regulated to some degree within the country, is for an external market and is ultimately regulated by standards set by the importing country. In a nutshell, there is often one set of standards for exports and another for the local market.

Foods for export

In practice, higher standards are usually demanded for foods prepared for export than for local use. Labour-intensive technologies of intermediate levels of sophistication sometimes present considerable difficulties in meeting these higher standards, particularly for meat and fish products. Approaches of this kind to the handling of prawns and frog legs prior to freezing, for instance, have led to microbiological problems and seriously damaged the export prospects of such foods from south-east Asia. In practice, an undesirable pattern has now begun to emerge with a tendency towards overtreatment, either thermal or chemical. Even with acid (fruit) products, efforts towards the use of semi-sophisticated technology in the preliminary stages of sterile packaging lines have been found in at least one instance to have been a cause of failure. Bearing in mind the basic levels of public health education and infrastructural development in many developing countries, the optimal technology for such situations is likely to be derived from small-scale technologies used–or perhaps superseded for non-technical reasons–in developed countries.

On the other hand, labour-intensive approaches involving later processing, such as the manual selection of ground-nuts, can produce acceptable results; but even in export-oriented industries where manual operations have long been accepted, increased attention to microbiological standards by importing countries may necessitate a change. In the decortication (removal of shell) of cashew nuts, intermediate-scale technology has provided an alternative to traditional manual operations.

Changes to more appropriate handling, preservation and processing technologies offer considerable prospects for improving the quality of certain food categories for export. Fresh-fruit handling, for instance, in hilly terrain where roads are poor, can be improved by the use of simple wireway systems (such as the Australian flying fox)–which have considerable advantages over wheeled transport–or even by such simple changes as use of a better-fitting container. Traditional types of produce-drying equipment have been improved, and can be further improved, by research and development, both in producing a better finished product and in reducing fuel requirements and costs. The importance of fuel economy is not, however, just one of immediate cost. In many situations the result of wasting fuel is accelerated deforestation. Long-term damage to the environment through erosion may prove to be an unacceptably high price for a community to pay. Technologists can help in evaluating methods of conserving fuel and recommending the most effective methods.

Foods for local use

The home markets and subsistence sectors of developing countries present even greater challenges to the technologist. People are naturally sensitive to suggestions that their standards should differ from those elsewhere–particularly when the suggestion emanates from an outsider. At the same time, pressures on food supply and the constraints that exist may necessitate compromises.

It is in this area that a technology that is intermediate in cost, size or level of sophistication is commonly assumed to be most advantageous. It is essential that any food technologist from outside the region working in this field should fully appreciate local conditions and views: the technologist must plan in the light of local circumstances and ensure an effective collaborative relationship with the most appropriate organizations of the region, and must bear in mind that the primary objective is to get beneficial techniques applied, rather than to develop research for its own sake, or to impose socio-political ideas. Getting people to use optimal techniques can be time consuming, but the time taken is almost invariably well spent.

The points already made can perhaps be briefly illustrated with a few examples.

Cane sugar

The importance of sugar as a food is worth special emphasis in view of India's position as the world's largest primary producer of sugar products. Small-scale sugar processing lends itself to the application of alternative techniques and processes, and the *khandsari* sugar industry, which annually processes some 10 million tonnes of cane, if made efficient, could be an optimal, rather than just an appropriate, industrial technology. In common with some other small-scale industries the *khandsari* industry is now suffering from a lack of research in processing techniques. Discussions about its viability in competition with the vacuum pan process, cannot therefore be extrapolated to the future until the techniques currently used have been carefully examined and where possible improved. It would otherwise be like comparing an unserviced old car with a well maintained, expensive new one. Obviously any alternative technique recommended for any stage of the process must be examined, not only in terms of its overall technical effectiveness, but also in terms of its socio-economic impact. This second phase must however await completion of research. Policy measures to incorporate improved processes and techniques must follow.

In studying the *khandsari* industry, the very strong impression is gained that most past research has been with the objective of making *khandsari* factories into miniaturized vacuum pan plants. This may well have hindered the development of the industry. In any activity, there is a particular scale at which it becomes sensible to change one's basic approach, for example from hand operation to machine operation or vice versa. Among factors influencing this decision are the availability and cost of suitable labour and the cost and efficiency of machinery. A change to a smaller operation opens the possibility of attendant changes, for example the opportunity for better examination of the raw material. As one reduces the scale of operation, it is obviously essential to consider novel possibilities often impractical at the larger scale.

The *khandsari* problems differ from those in the vacuum pan industry. It seems reasonable therefore to look for different solutions. TPI is in consultation with the appropriate authorities in India on the formulation of an R and D programme which could possibly become the first step towards a major improvement of the *khandsari* industry. Every step of the operation is to be examined, first to establish its efficiency, then to try out alternative techniques that can be slotted into an existing operation, and finally to put together what may prove to be a rather different design of plant.

The initial emphasis must be exploratory—not enough appears to be known about such fundamentals as where and how heat and sugar are lost and what these losses cost. The initial investigatory work will provide a baseline against which small benefits can be recognized. This is important, as a number of small benefits can add up to a substantial improvement. In the proposals made by TPI a number of areas for study have been identified. A cost-benefit study which might lead to improved efficiency should be conducted in such areas as the following:

- Discard of recognizably bad canes for alternative use
- Improved cane preparation
- Mill-roll design
- Effective yet simple mill sanitation
- The use of maceration water
- The effectiveness of second and third mills
- Phosphate supplementation
- Alternative approaches to clarification
- Reduction of sugar losses
  - Improved pan design
  - Re-assessment of the best pH for boiling
  - Elimination of dead spots
- Increased molasses exhaustion
  - Pan densities
  - Cooling regimes during crystallization
- Minimizing water addition
- Fuel economy
  - Improved furnace design
  - The effect of pan scale
  - Non-evaporative heat losses particularly during crystallization
  - Extension of operating runs
  - Use of flue-gas waste heat

After the investigations, implementation of alternatives should be considered in the light of cost-benefit effectiveness, social acceptability and other considerations of broader significance.

Fish products

A less expensive alternative to the freezing of fish has been developed as a result of studies of microbiological and enzymatic spoilage of tropical fish. Use of the technology resulting from these studies has made possible the storage of certain species of tropical fish for periods of a month or more simply by chilling.

Another recent development in solar drying being applied in Guyana maintains the product at a temperature at which insect eggs are dormant, a considerable advance on traditional air-drying techniques. Where traditional local techniques must continue to be employed, improved hygiene, selection of fish to be dried and careful use of pyrethrins can show considerable improvements in the quality of the material removed at the end of a period of storage.

Oil-seeds

In the edible oils industry there are a number of examples where internal standards of quality in a developing country are markedly different from those required for exports. In Western Europe and the United States of America, bland, clear, lightly coloured edible oils and fats are usually preferred, and crude oils and fats must therefore be decolourized, clarified and deodorized for these markets. With palm-oil, coconut, ground-nut, and rape-seed and mustard-seed oils, the inherent flavour and colour of impurities in the oil play an important part in the appeal of the final dish, and people in producing areas often therefore prefer unrefined oil for domestic use. Bland refined oils and fats are increasingly finding favour in developing countries, however, particularly in the more affluent sectors of the population.

Natural edible oil-bearing materials vary considerably in oil content, varying from the 65–70 per cent found in oil-palm fruit and copra down to cotton seed and soya beans in the region of 15–20 per cent. Several simple manual or animal-powered techniques have been evolved for extracting oil from high-oil-content crops such as copra, oil-palm, sesame, ground-nut and mustard-seed, but all tend to be somewhat inefficient, often removing less than 50 per cent of the available oil.

One cannot avoid the reality that expelling oil from oil-seeds requires high pressures and consequently considerable energy input. For the low-oil-content oil-seeds, and for the efficient removal of oil from any crop, powered screw expellers or solvent extraction is necessary. In some socio-economic environments, such as rural areas with low income, no electricity and poor communications, there may be no alternative to the use of simple methods and consequently the inefficient extraction of oil. In general, the use of more efficient, powered screw expellers is to be encouraged where the primary objective is to make optimum use of available raw materials.

Continuous automatic operation of an edible oil factory is feasible on a large-scale, but in smaller factories batch processing is generally found. The key to efficient operation in all cases is close routine monitoring of certain critical steps in the process. The establishment of process control procedures in even the smallest factory has resulted in improvements in end-product quality and reduced losses and costs. Continual routine checks can and should be made on raw materials, and pre-treatment can be confirmed by simple measurement of oil in cake and foots in oil. Such simple tests can indicate the need for minor adjustments to control losses or operating costs, or perhaps indicate the need for repairs. In refining, simple procedures can determine, for example, the correct quantity of lye or bleaching earth required, so reducing overtreatment and waste.

Efficiency of ancillary equipment must be considered in any technical review of factory operation. Generators, boilers, motors, pumps etc. should be subject to routine maintenance and consideration must be given to lagging steam lines, hot-water lines and all heated vessels to reduce energy losses and consequent fuel wastage.

Food-grain processing and storage

Efficient utilization of fuel is as important in milling as in the production of edible oils or sugar. By chance two engineers working on paddy drying in Bangladesh recently observed that by siting a husk-fired steam boiler in a rice mill considerable savings would be obtained both in laying the connecting pipe and, more importantly, in reducing heat losses. Further substantial heat savings could be obtained by lagging the pipe. These savings, could well determine whether the mill would be viable or an economic failure. Their recommendations were promptly put into effect.

Engineers and technologists at the International Rice Research Institute (IRRI) adapted the technology used in large-volume paddy threshers to produce the successful IRRI portable paddy thresher. Similarly, technologists in Egypt, India and Pakistan have further modified the portable unit to thresh wheat and barley, and to further improve its efficiency.

Techniques for large-scale storage of grain can often be used on a small-scale, but a major difficulty in adopting them is that of communication. Godowns and small silos of improved design can certainly be built by local craftsmen, but the instructions must be written in the local language and measurements given in units they understand. Construction materials should be those familiar to the local craftsmen. Frequently designs have to be modified to permit the use of locally available material. Illustrations and models must be clear. Conventional symbols may make an idea clear to someone from a developed country, but someone from a developing country may derive a totally different meaning from them.

For storing smaller quantities the use of metal bins can be encouraged, if necessary, in a number of ways, including soft loans and subsidies. Both of these approaches have been successfully used in India in the "Save Grain Campaign" to improve the quality of storage systems.

Sacks for dried materials can be made from many materials, ranging from natural or synthetic fibres to woven strips of polythene or plastic sheet. The use of pesticides for additional protection is even more advisable when sacks are used than when bins are used. Unfortunately pesticides are usually supplied in bulk so there is a widespread need for small enterprises to break down bulk quantities into small packets suitably printed with instructions understandable to the small-scale user to encourage wider use.

Starch

Starch extraction is a traditional technology in many developing countries. In some, the traditional is no longer the optimal, a fact that may be illustrated by reference to sago starch, a traditional product of swamp areas of south-east Asia.

A local export market in sago starch has long existed, and a wider market, particularly to the United Kingdom, gradually developed. As the market grew, the traditional household methods of preparation became inadequate to meet the demand, and the processes used were mechanized. The present factory process used in Sarawak is a very interesting example of indigenous enlargement of a cottage industry to the scale of a small factory, with apparently very little benefit derived from external experience and expertise.

Unfortunately, requirements in the United Kingdom have changed, and the quality of the starch now produced is too low for European manufacturers to risk putting it into their food products. As a result, the export trade to Europe has virtually disappeared, and exporters have to sell sago starch for whatever they can get, mostly to stock feed merchants in markets closer to home.

The techniques used in the factory can be improved by using ideas imported from other areas where starch is produced on a small-scale in unsophisticated plants. Preliminary proposals have been adopted and substantial improvements in quality have already been realized by individual factories. It is likely that some modifications to the imported methods and equipment will lead to further improvements. There is a role here for people who understand the underlying principles of the technologies concerned. The Government is now setting up a laboratory that will serve as an extension centre to stimulate improvements in starch quality and to monitor maintenance of these improvements with the ultimate objective of reviving the export trade of sago starch fit for human consumption. The objectives of the project are to increase the efficiency of extraction and to help the local people obtain a better price for their product without significantly changing the technical or economic requirements of the manufacturing process.

The experience of Burma

*M. Thant Tyn**

Background

In Burma the agricultural sector is the mainstay of the economy. The products contribute about 27 per cent of the gross national product and earn more than 80 per cent of foreign exchange [1]. Consequently, priority is accorded in the 20-year long-term and 4-year short-term development plans of Burma to increased production, export promotion, utilization of raw material for agro-based industries and import substitution.

Measures taken included multiple and mixed cropping, increasing irrigated areas, distribution of inputs such as quality seeds, fertilizers, insecticides at cost or even at a loss subsidized by the Government, loans and advance purchase schemes, reclaiming fallow land, promoting the use of draught cattle and agricultural implements, and fixing fair prices for products. As a result, agricultural production began to increase by approximately 5 per cent annually from 1975 to 1976 [1]. Since food crops are about 95 per cent of the total, the simultaneous development of food storage and processing technology was anticipated.

The other sector requiring food storage and processing is fisheries and livestock. *Per capita* consumption of fish and meat has increased by about 4.5 per cent annually since 1974/75, and in 1977/78 it was about 16.95 kg and 3.63 kg respectively. However, such a rate of consumption was still low (even taking account of eggs and milk) and could contribute only 25 per cent of nutritional requirements [2, 3].

Fish resources have been exploited only to a limited extent. The coastline constitutes about 27 per cent of the territorial frontiers [4] and the enormous marine resource potential is to a considerable extent untapped. There is also a reasonable potential for freshwater fishery. About 32 per cent of the land area is covered with fresh water and about 80 per cent is currently utilized [5]. Newly constructed dams and irrigation systems have great potential for freshwater fish farming. For meat production an appreciable amount of land is left uncultivated and suitable for cattle breeding [5]. Some difficulties in the supply of feed, animal medicines and selected species of livestock were encountered, but practical efforts to solve the problems have brought a steady increase in production.

As in many developing countries, most storage facilities for food are not

*Head, Research and Development Division, Food Stuff Industries Corporation, Rangoon, Burma.

entirely adequate and food-processing machinery is old. Replacements from developed countries would be costly and part replacement could be incompatible. Hence indigenous resources, technology and know-how have to be utilized wherever possible. In addition, technological know-how from other developing countries such as China, the Democratic People's Republic of Korea and India have been adopted because these countries have difficulties of much the same kind. Current emphasis in Burma has thus been on adaptability and suitability to the local conditions and practical use. It is believed that in time a mix of transferred appropriate technology with the improved methods could be fruitful.

The territorial area of 261,228 square miles (676,581 km^2) is bound on the north and east by mountains, on the south by the Andaman Sea and east by the Bay of Bengal. The main crop is rice and major exports are rice, timber, other agricultural products, and base metals and ores in percentages of 52 per cent, 27 per cent, 10 per cent and 3 per cent respectively [5]. About 24 million acres (9.7 million ha) of a total of approximately 45 million acres (18.2 million ha) of arable land are cultivated. The population in 1978 was estimated at 32.2 million, an increase of 2.2 per cent over the previous year. The most populated regions are Irrawaddy Division, Mandalay Division, Mon State, Pegu Division and Rangoon Division, with densities of 307, 257, 275, 208 and 813 inhabitants per square mile (119, 99, 106, 80 and 314 per square kilometre), respectively [4]. The total labour force in 1977/78 was about 12.6 million, of which 8.2 million (65 per cent) and 0.93 million (7.4 per cent) were in the agricultural and industrial sectors.

Food storage and processing know-how

Sice 1962 Burma has emphasized the utilization of indigenous resources and know-how while industrializing various sectors. Unnecessary imports were restricted, most spare parts and essential machinery being designed and manufactured in the country. As a result, Burma now possesses considerable appropriate technological know-how and manufacturing techniques and can in some cases offer technology to other developing countries.

Food grains

Since food grains, especially rice, are the staple food and earn foreign exchange, they account for the majority of the factories. They constitute about 80 per cent of diets and are also the main sources of food energy and proteins. However, according to the provisional figures there are 4,159 state-operated grain storage houses with a capacity for about 2.3 million tonnes, only about 46 per cent of the total rice production. About three quarters of the storage is in permanent buildings, usually with cement flooring, 16 per cent in temporary buildings with wooden floors and the rest in bamboo structures for seasonal use [6]. Plans are being made to construct about 160 prefabricated warehouses and three silos of improved design.

To solve the problem of grains soaked by unexpected rain, a simple dryer was developed by the farmers using corrugated roofing sheets placed over a flue dug into the ground. The soaked grain is spread thinly over the sheets and straw burnt at one end, so that heat spreads through the sheets as the hot gases pass through the flue and out of a bamboo mat smoke-stack at the other end. Although simple, the method is effective for a small farm. Large quantities of rain-soaked paddy, however, are processed by the parboiling method in mills. Only 20 per cent of the mills are on a large commercial scale, with a total capacity of 8,988 t every 8 hours [6]. Since the demand to parboil rice and to salvage rain soaked paddy is expected to grow, it is desirable to improve the parboiling technology. Although small-scale rice mills could be manufactured locally, this indigenous technology is inadequate for producing high-quality exportable or parboiled rice. Therefore some foreign technology, especially from developing countries, should be sought to complement existing methods.

Technology for utilizing by-products from rice mills, i.e. solvent extraction of edible oil from rice bran has, however, been well established, and the majority of the factories were designed and constructed locally. Commercial hexane from local petroleum refineries is used. The major problem here is the rapid increase of acidity free fatty acid (FFA) in raw bran during transportation from mill to oil factory, mainly due to the active lipase enzyme in the bran, which starts splitting the oil by hydrolysis [7, 8] as soon as the bran is separated during milling. Within 24 hours the FFA rises to between 12 and 25 per cent. It is uneconomical to process high FFA edible oil, so the bran must arrive within 24 hours after milling. This can be difficult owing to the dispersed location of the existing mills and some constraints in transportation. The problem is being solved by heating at 105°C to 110°C for 10 to 15 minutes and adjusting the moisture content of the treated bran below 10 per cent. The bran can then be kept from three weeks to a month with no appreciable rise in the FFA content [8, 9]. At present 32 stabilization units are scheduled to commence production in 1979.

Oil-seeds and vegetable protein

The average daily consumption of vegetable fat in Burma is about 11 g *per capita* as against a nutritional requirement of nearly 60 g.[1] Existing resources of oil crops are reasonably large and the potential is rather high. Oil production in 1976/77 was only about 80 per cent of the potential output, because mills are old and most are small units scattered throughout the country. The majority of mills use the screw expeller machines; some combine expeller and oil presses. The traditional rural method of oil extraction is by *hse-zons* (presses) which are worked either by bullocks or a small motor. At present there are no solvent extraction plants. Since the technology of solvent extraction of bran oil, which can be adopted for the solvent extraction of oil-seeds, is well established in Burma, solvent oil-extraction facilities may be introduced in conjunction with expellers. Although the method is expensive and has substantial initial capital costs, oil production could be increased by 10 to 15 per cent by its use.

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[1]Food and Agriculture Organization of the United Nations (FAO) estimate, 1978.

Marine products

Plans are being implemented to expand fish production in Burma with the help of the Asian Development Bank. The major preserved fish product consumed daily is *nga-pi* (fish paste), without which no Burmese lunch or dinner is complete. Traditionally, *nga-pi* is made by drying fish or prawns by solar heat for three to four days and then pounding manually or mechanically, adding salt at intervals. The homogeneous mixture is stored in earthern jars or bamboo warehouses and the surface covered with salt for at least three to four months. The liquid coming from it during storage is collected as fish extract [10].

Some research work has been undertaken on the action of salt in the manufacturing process and on *nga-pi* quality. It is believed that as soon as the fish or prawn dies, proteins in the tissue cells are first split by hydrolysis into peptone and peptide with the help of cathepsin enzyme and then split further to animo-acids and ammonia by the process of autolysis. If contamination by outside bacteria occurs during the process, the animo-acids are decomposed into amines or ammonia and carbon dioxide and could give rise poisonous products. The autolysis and putrefaction of protein can be prevented by drying or osmosis using salt water. Salting removes water from the tissue cell, deactivates enzyme activity and prevents the entry of bacteria. The minimum salt concentration in the fish for this purpose is 4 per cent, but at about 20 per cent concentration the fish or prawn can keep at room temperature for about two to three years [11, 12].

Hygiene is an important factor for *nga-pi* processing, storage and marketing. The major contaminant is dead flies [13], which can cause intestinal myiasis. Manufactured hygienically, however, *nga-pi* is nutritive; its caloric content is comparable to beef, pork and mutton, and it contains a high percentage of calcium and phosphorus [10]. The annex gives the Burmese standards for fish and shrimp paste.

Therefore good quality *nga-pi* is usually obtained by reprocessing in a large-scale factory using high-power grinders. In Rangoon there are three large state-owned factories reprocessing *nga-pi* from rural areas. Technology is needed to promote quality *nga-pi* products from the dispered or decentralized small-scale manufacturers.

Dried and pickled fish (or prawns) help to meet internal market demand and also have export potential. Smoking is practised only with one type of fish, *nga-gyi*, though herring, cod, haddock, mackerel and others are smoked in other countries. Appropriate technology of smoking to mix with the traditional method might lead to the promotion of new varieties in Burma. Solar drying is used extensively. Smaller fish are simply spread out on the beach and left to dry for a few days. Larger varieties are usually gutted, sometimes cut into strips leaving the tail untouched and salted before drying. There are cases where a very large fish is not salted due to the belief that this salting would spoil the natural flavour. Instead, the flesh is sliced into thin strips to accelerate drying. Spread and supported by a bamboo ring to ensure the maximum exposure, it is then hung by the head. Since dried fish has export potential, efforts should be made to improve both this traditional method and pickling. Pickled fish is a favourite preserved fish, but its use is restricted owing to the present inadequate know-how. The method now is to mix fresh fish with freshly cooked rice, the pickling medium being vinegar from the fermentation of cooked rice. It is then packed hard and airtight, although the packing system could also be improved [14].

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Annex

STANDARDS FOR FISH AND SHRIMP PASTE

Fish paste

Fish paste *(nga-pi)* as sold, offered or exposed for sale or manufactured for sale shall conform to the following standards: [a]

(a) Quality. The fish paste shall be a product made by the processes of salting, drying and grinding from sound, clean, fresh fish. No foreign matter shall be present. Only permitted dyes may be used;

(b) Inspection. The analysis of the fish paste shall conform to the specifications given in table 1;

TABLE 1. FISH PASTE SPECIFICATIONS

	Percentage	
Component	*Maximum*	*Minimum*
Water	40	
NaCl	25	
Protein		18
Fat		1.5
SiO_2	1	
Mineral salts other than NaCl	8	

(c) Bacteria. The bacteria count should not be more than one million per gram of *nga-pi* incubated at 37°C. The following bacteria [13] should not be contained in *nga-pi:* coagulase positive staphylococci, salmonellae, and coliform bacilli.

Shrimp paste

Standards and specifications for shrimp paste (*hmyin nga-pi)* as sold, offered or exposed for sale or manufactured for sale must conform to the following standards:[b]

(a) Quality. The shrimp paste shall be a product made by the salting, drying and grinding process from sound, clean, fresh shrimps. The adding of cereals (such as starch and bran) is prohibited. Only permitted dyes may be used;

(b) Inspection. The analysis of shrimp paste shall conform to the specifications given in table 2.[c]

[a] Union of Burma Food Standards and Specifications (UBFSS), provided for under the Union of Burma Public Health Law (1972), Ministry of Health, Burma, 1972.

[b] *Ibid.*

[c] H. Wittfogel, "Grading commercial values of shrimp paste *(hmyin nga-pi)* in Burma and detecting adulterations with fish and shrimp peels in it", *Journal of the Burma Research Society*, 1960.

TABLE 2. SHRIMP PASTE SPECIFICATIONS

Component	*Percentage*	
	Maximum	*Minimum*
Water	40	
NaCl	25	
Protein		18
Fat		1.5
SiO_2		1
Mineral salts other than NaCl	8	
Free ammonia	1	
Fish	15	

Appropriate technology for food-grain storage under Indian conditions

*N. S. Aggarwal,** *B. R. Birewar,*** *K. K. S. Chauhan,****
G. K. Girish,† *S. N. Sharma,*†† and *B. K. Verma,*†††

INTRODUCTION

With the development of Indian farm technology and the consequent increase in agricultural production, storage facilities created for subsistence farming have not simultaneously adapted to the change brought about by commercialized farming. Increased productivity cannot be translated into a proportionate increase in the level of real incomes in an economy in which the storage system is inefficient. Hence, the economic need for an appropriate and efficient storage system is imperative.

Food grains in India account for about 75 per cent of the gross cropped area. Their production over the last 28 years has shown a significant increase, achieving a level of 125 million tonnes in 1977/78 from a level of 52 million tonnes in 1967/68 and 28.8 million tonnes in 1975/76. Simultaneous introduction of high-yielding varieties in the late 1960s contributed largely to the remarkable increase from 11.4 million tonnes in 1966/67 to 16.5 million tonnes in 1967/68 and 28.8 tonnes million tonnes in 1975/76. Simultaneous efforts were made to increase production of paddy and other cereals by introducing high-yielding varieties and applying fertilizers, insecticides and pesticides. Production of about 49 million tonnes of rice in 1975/76 indicates potential for a similar breakthrough in the future. There has been a rapid extension in the area under high-yielding varieties, indicating a high degree of response from farmers.

Since Indian agriculture largely depends upon agro-climatic and monsoon conditions, the precise forecasting of food-grain production is difficult. Organizations such as the Administrative Staff College of India (ASCI) and the

*Joint Commissioner, Department of Food, Ministry of Agriculture and Irrigation, New Delhi, India.

**Senior Agricultural Engineer, Indian Grain Storage Institute, Hapur, Uttar Pradesh.

***Commercial Manager, Food Corporation of India, New Delhi.

†Deputy Commissioner, Ministry of Agriculture and Irrigation, New Delhi.

††Deputy Manager, Food Corporation of India, New Delhi.

†††Director, Indian Storage Institute, Hapur, Uttar Pradesh.

National Commission on Agriculture (NCA) have made projections, and a level of 164 million tonnes has been suggested by 1985, rising to 230 million tonnes by the end of the century.

MARKETING SYSTEM

Regulation of markets was initiated with a view to bringing about orderly marketing of agricultural produce and to regulating charges and practices. Agricultural Produce Marketing (Regulation) Acts are in force in 18 states and four union territories. Of the total of 4,145 markets, nearly 3,000 have already been regulated.

Of the total food-grain production of India, about 60–70 per cent is retained on the farms for family consumption, seed, feed and other purposes. The surplus for marketing is thus estimated to be about 30–40 per cent.

Almost all those engaged in the process of marketing are faced with the problem of storage. The various storage agencies are the producers, merchants, transport agencies, warehouses, the public and state agencies and the consumers. In view of the wide variations in objectives, problems of storage vary significantly.

In terms of absolute quantities, farm storage is very large compared with both trade and public storage, and was even greater before the Second World War. Private trade also plays a major role. It is estimated that 70–75 per cent of the marketable grain surplus is stored by traders for periods of time and purposes which may vary from place to place. Nevertheless, the facilities of public agencies have increased fourfold over the last 15 years.

The total capacity owned by the Food Corporation of India (FCI), the Central Warehousing Corporation (CWC) and the State Warehousing Corporation (SWC) increased from 2.5 million tonnes in 1965/66 to 9.7 million tonnes in 1977/78.

GOVERNMENT PROGRAMMES AND POLICIES

The main food policy objectives of the fourth five-year plan were as follows:

(a) To stabilize consumer prices and safeguard interests of the low-income consumers;

(b) To ensure reasonable prices and incentives for increasing production;

(c) To build up a buffer stock of grain as a safeguard against shortages and high prices, or to support falling prices.

Measures along the following lines have been taken from time to time:

(a) Introduction of a public distribution system for the acquisition of stocks;

(b) Regulations to curb speculation and hoarding;

(c) Restrictions on the movement of grain;

(d) Regulation of bank advances against grain;

(e) A ban on forward trading.

Minimum support and procurement prices are fixed by the Government of India on the recommendations of the Agricultural Price Commission. Effective implementation has increased confidence among farmers and encouraged a growing rate of capital formation.

The quantity of food grain distributed has averaged more than 10 million tonnes per annum. A network of 240,000 fair-price shops serves 566 million people in rural and urban areas.

The Government of India has decided to build up a buffer stock of 12 million tonnes, over and above the operational stocks needed for the public distribution system, which range between 3.5–3.8 million tonnes in April and 8.2–8.8 million tonnes in July. The Government is further considering a buffer reserve of 14 million tonnes by 1982/83.

Storage requirements to maintain buffer reserves and peak operational stocks of 9 million tonnes, with an operational margin of 8 per cent, work out at 23 million tonnes at present and 25 million tonnes by 1982/83.

SOME PROBLEMS OF GRAIN STORAGE

Important post-harvest problems of food-grain storage concern drying, handling and losses.

Multiple cropping has led to a higher moisture content in grain at the time of harvesting, while the coincidence of harvesting with rains in some areas causes severe problems of drying and threshing. Sun drying is largely resorted to at present. Mechanical dryers are used occasionally.

Grain is handled manually. To keep pace with the increases, efforts are being made to introduce mechanical handling.

Various loss estimates have been made. The Government of India Expert Committe on Post-harvest Losses (1967) estimated that food-grain losses at various stages account for 9.33 per cent of production. Storage loss was put at 6.58 per cent, and threshing, transport and processing at 1.68 per cent, 0.15 per cent and 0.92 per cent, respectively. ASCI recently reported a 5.25 per cent loss for 100 million tonnes in the stages of storage and transportation. On the other hand, the percentage of losses over a number of years in the FCI, including quantitative losses due to moisture variations, are less than 1 per cent of the quantity sold, as shown below:

Crop year	*Losses as a percentage of the quantity sold*
1971/72	0.7
1972/73	0.4
1973/74	0.5
1974/75	0.5
1975/76	0.3

CAUSES OF LOSSES

Various agencies have estimated grain losses due to different factors, as reflected in table 1.

TABLE 1. ESTIMATED GRAIN LOSSES
(Percentage)

	Source of estimate				
		ASCI and public agencies			
Cause of loss	Expert Committee	Farm level	Trade	Conventional godowns	Silos
Insects	2.55	3–4	3–4	0.5–1.0	0.5
Rodents	2.50	0.5–1.0	0.3–1.02	–	–
Birds	0.85	–	0.2	0.2	–
Moisture	0.68	–	0.2	0.2	0.2
Other	–	–	0.3	0.3	–
Total	6.58	5.0	5.0	2.0	1.0

Sources. Interim Report of the Government of India Expert Committee on Post-harvest Losses; Administrative Staff College of India

Insects: Under Indian conditions, the most important insec. pests of stored grains are the following: *Sitophilus oryzas* Linn (rice weevil), *Rhizopertha dominica* Fab. (borer beetle), *Trogoderma granarium* Everts (khapra beetle), *Sitotroga cerealella* Olivier (grain moth), *Corcyra Cephalonica* Staint (rice moth), *Ephestia cautella* Walker (fig or almond moth), *Callosobruchus* (beetle), *Oryzaephilus surinamensis* Linn (saw-toothed grain beetle), *Lathaticus oryzae* Water (long-headed flour beetle) and *Plodia interpunctella* Huebn (meal worm moth).

The lowest temperatures at which the grain insect pests can develop are between 15.5° C and 18.3° C. Moisture content is also a factor, with optimum conditions of insect damage at 14 per cent, the level at which other deterioration also sets in. This is therefore considered the highest level of moisture for safe storage of grain. Generally, insect infestation tends to increase with a moisture content above 10 per cent. Various technologies are now available in India to control insects.

Rodents. Efforts are being made by the Government to reduce the rodent menace, and storage has reduced losses to negligible levels. This is a social problem, and religious or humanitarian sentiments have to be borne in mind. The success of a campaign depends upon an integrated approach involving environmental control, education, the active support of the people, and the training of skilled operators.

Moisture. It is not always possible to store grain at the minimum 10 per cent moisture content. When the moisture content goes above 14 per cent, problems arise. Excess moisture causes wet grain heating due to the attack of micro-organisms, producing temperatures as high as 144° F (62.2° C). Insect attacks cause dry grain heating up to 108° F (42.2° C).[1]

[1]G. K. Girish and others, "Conventional grain storage practices and losses in rural areas of Uttar Pradesh", *Bulletin of Grain Technology*, vol. 12, No. 3 (1974), pp. 199–210.

The moisture of stored grain in due course tends to come into equilibrium with air humidity, gaining or losing moisture as the relative humidity increases or decreases. Relative humidities above 65 or 70 per cent can cause fungi, and below 70 per cent lead to insect breeding. A moisture content equivalent to a relative humidity of 65 per cent has been suggested for two to three years storage of grain and grain products held at 60°–70° F (16°–21°C), while at a relative level of 72 per cent grain can be stored for only three months at the same temperature. It has also been observed that grain stored in bags has more moisture than that stored in bulk, but damage due to fungus attack and heat is higher in the latter.

Girish and others,[1, 2] Srivastava and others[3] and Doharey and others[4] have recorded substantial variations in the moisture content and temperature of grain stored in various types of container, and have observed in detail the effects on different grains.

It has been shown that wheat containing about 17 per cent moisture lost approximately 30 per cent thiamine in five months. Above 25 per cent grain, especially maize, tends to become very dark, soft and unfit for breadmaking. At 18–20 per cent moisture the gluten quality is affected. Dry matter loss of 2 to 4 per cent for barley with a moisture content of 22 and 35 per cent respectively is reported. In paddy the critical level is 11 per cent at 24°–31°C temperature in metal bins.

STORAGE ON FARMS[5]

Priority should be given to improving farm storage facilities because of the large quantitiy of grain retained by farmers and the fact that storage losses have been observed to be greater.

The farmer uses structures constructed from locally available materials. Generally speaking, grain meant for long-term storage is stored in structures or containers specially designed for it; grain meant for disposal or short-term use is kept in bags or heaped in a corner.

Some of the most common indoor and outdoor structures are made of mud and split bamboo. In such structures grain is usually damaged by insects, fungus and rodents, and fumigation is ineffective.

Improvement in farm storage facilities can be made either by new designs or by improving the existing structures. Efforts are being made by several

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[2]G. K. Girish and others, "Studies on preservation and losses of food grains in underground pits", *Bulletin of Grain Technology*, vol. 10, No. 1 (1972), pp. 11–21.

[3]P. K. Srivastava and others, "Conventional grain storage practices in rural areas of western Uttar Pradesh", *Bulletin of Grain Technology*, vol. 11, No. 2 (1973), pp. 129–139.

[4]R. B. Doharey, P. K. Srivastava and G. K. Girish, "Studies on the assessment of losses of wheat in Punjab", *Bulletin of Grain Technology*, vol. 13, No. 3 (1975), pp. 159–161.

[5]See B. R. Birewar, "Scientific storage facilities at farm level", paper prepared for the FAO/NORAD Seminar on Farm Grain Storage in India, in collaboration with the Government of India.

organizations to develop new designs. The Indian Grain Storage Institute (IGSI) has developed designs of indoor and outdoor bins and rural structures for capacities of from 0.09 to 14.5 t. Some designs are mass-produced in nearly 19 states and one union territory under the "Save Grain Campaign" Programme of the Department of Food.

Indoor bins

Domestic designs. Different types of domestic designs of metal bins have been developed, with capacities ranging from 3 to 27.5 quintals of wheat. Different capacities of the bins have been developed using galvanized plain sheets of different standard sizes available on the market. These bins are moisture-, rodent- and insect-proof and have been found to be suitable for storage of wheat, paddy, maize, pulses and seed grains.

Gharelu thekka. With a capacity ranging from 2 to 3 tonnes, *gharelu thekka* is a portable and economic type of storage structure consisting of a rust-proof, metal-based, rubberized cloth container and bamboo posts.

Pucca kothi. This type of structure is constructed using burnt bricks plastered with cement mortar. It is divided into two compartments, each with a capacity of 10 t. Depending on the space available, the structure can be enlarged to include more compartments.

Welded wire-mesh bin. This bin of 4 m^3 or 2.8 t capacity was designed to store grains such as paddy and maize, even at a slightly higher moisture level. The bin is manufactured using wire mesh with a hessian cloth lining so that air may circulate freely. The structure is mounted on a prefabricated, elevated steel base to prevent the entry of rodents.

Reinforced cement-concrete ring bin. Consisting of prefabricated reinforced cement-concrete rings placed one over the other with gripping joints at the edges, the reinforced cement-concrete bin can be constructed with or without a masonry base. The capacity of the structure can be varied by increasing the number of intermediate rings and keeping the bottom and top the same. Although the structure is preferably used for indoor storage, if adequately waterproofed it may also be used outdoors.

Paddy-straw mud structure. The prototype unit with a capacity of 400 kg is made of paddy-straw rope plastered on both sides with specially prepared mud. The outside is further plastered with a waterproof mud to prevent the entry of moisture. The structure is provided with a suitable outlet and inlet and is mounted on a raised brick masonry platform to prevent the entry of rats.

Outdoor bins

Flat- and hopper-bottom metal bins. Constructed with either steel or aluminium metal sheets for different capacities ranging from 2 to 10.5 t, these bins may be mounted on a base or columns of brick masonry, or on a prefabricated, elevated steel base. A simple lifting device provides a means of loading the grain manually. The bins are found to be suitable for storing wheat, paddy and maize under different climatic conditions. The aluminium is rust-proof, and periodical maintenance is not necessary. Its reflecting surface has an additional advantage of keeping the grain cool by radiating heat quickly.

Composite bins. These outdoor flat-bottom storage bins are manufactured by using a combination of steel and timber. The use of timber battens at the wall and roof joints will help to resist the lateral pressure, thus making it possible to use thin sheets in this design. Structures of 12 different capacities ranging from 3 to 14.5 t can be manufactured for storing wheat. This design has been developed with a view to limiting the use of steel and making the structure economical.

R. B. bins. This design consists of two layers of brick masonary walls, each 4½ in. (11 cm) thick, with a moisture barrier in between. The outer layer is reinforced with steel and plastered on both sides with cement mortar. It has a flat floor on the bottom and a reinforced cement-concrete roof on top. In this design, structures with four capacities ranging from 3.5 to 10.25 t may be constructed.

Partly underground and partly above-ground storage structures. A partly underground and partly above-ground prototype structure of 10 m^3 or 7.5 t capacity has been designed and constructed. The underground part of the structure is of reinforced cement-concrete brick, while the above-ground part is of galvanized plain sheets. A means of unloading the grain mechanically as well as manually has been provided. This bin is suitable for construction in shallow water-table areas.

Hermetically sealed, underground structures. In a hermetically sealed storage structure, moulds do not develop on damp grain, and insects do not survive because of the low concentration of oxygen. Prototype units of hermetically sealed, underground welded steel structures, with a capacity of 1.4 t, and reinforced cement-concrete structures, with a capacity of 3.4 t, were developed to facilitate the storage of grain free from insect and mould damage. The metal structure is manufactured from mild-steel sheets with welded joints and painted on the outside with two coats of bitumen paint. Similarly, the reinforced cement-concrete structure is also painted with two coats of bitumen paint. Both structures are placed below ground, leaving the top 50 cm above ground level. Adequate sealing arrangements are provided at the inlet.

Urban-cum-rural grain and seed storage bins. These are either circular or square in shape with 6 different capacities ranging from 90 to 300 kg using different standard sizes of galvanized plain sheets. The height may be either 0.5 m or 1 m. In small capacity bins with a height of 0.5 m no outlets are provided. The circular bins are easy and economical to manufacture, while the square bins are convenient to keep in the corner of the room without loss of floor space. These bins of small capacities are developed specifically for use in urban areas where a small quantity of grain has to be stored for domestic use. They are also preferred in rural areas for storage of seed grains.

An effort is being made in other organizations to evaluate low-cost storage units such as mud or timber structures, ferrocement bins, high-density polythene structures etc.

Ferrocement bins of capacities ranging from 0.6 to 3 t for indoor and outdoor use have been developed by the Structural Engineering Research Centre, Roorkee, and some other organizations. The bin is constructed using rich cement mortar and closely spaced, chicken-wire-mesh. The bin is cylindrical in shape and has a flat bottom and dome-shaped roof. The thickness of the structure is normally 25 mm. The bins, particularly those for outdoors, have to be treated externally with suitable moisture-proof paint, such as bituminous aluminium paint.

The outdoor bins have to be placed on a prefabricated, raised, brick masonry platform. They are lighter in weight than the cement concrete structures, and frequent maintenance is not necessary. This design may also prove to be promising for farmers.

The *pusa* bin has been developed by the Indian Agricultural Research Institute, New Delhi, for indoor use. This design consists of two brick walls, each 4½ in. (11 cm) thick, using sun-dried bricks with polythene sheeting sandwiched in between. The structure is mounted on a brick masonry platform plastered with cement mortar. A mud slab is provided at the top on a wooden frame structure. A polythene sheet is also provided at the top and the base to make the structure completely moisture-proof and airtight.

Improvement of existing storage structures

A number of improvements in the existing storage structures have been suggested by different workers. The Indian Standards Institution (ISI) has suggested improvements in underground storage structures. The suggested improvements include the use of bitumen, polythene sheets and dense cement concrete in the construction of a structure to make it impervious to subsoil water. ISI has also published codes of practice for the construction of farmers' grain storage structures such as *bukhari, murai, kothari* etc. The necessary technical improvements have been carried out at the ISI in respect of certain existing storage structures such as *puri, gade,* mud structures, earthern pots, and oil drums.

Puri. The local *puri* is an outdoor storage structure made from paddy straw. The paddy in such a local storage structure is usually damaged due to rodent and ground moisture or water. An improvement has been made in the local structure by introducing a water- and rodent-proof base constructed by using different locally available materials such as steel, cement concrete and bricks. The base is in the form of a ring which is nearly 60 cm above ground level. The base floor is constructed of brick, stone or cement concrete with a 600-gauge polythene sheet embedded in it to prevent the penetration of subsoil moisture. The prefabricated base provides stability to the *puri* structure and also helps to maintain its true shape.

Gade. The *gade* is an outdoor as well as indoor structure made of split bamboo and usually placed on a low platform. This type of structure is quite common in different parts of the country and is usually attacked by rats. Improvements have been made by introducing different types of rat-proof raised platforms using different locally available materials. Proposed improvements include the following: a timber platform with anti-rat steel cones fitted on the legs to prevent the entry of rats; provision of a timber platform with a steel base at the bottom of the structure; and a brick or stone masonry platform with a stone or concrete slab.

Mud structures. Such structures are commonly used indoors in different parts of the country. They are usually placed on a low platform, and have inadequate unloading facilities. The grain stored in such an indoor storage structure is usually damaged by moisture, insects and rats. Improvements are therefore necessary to make the structure moisture-proof, rat-proof and suitable for fumigation purposes. The suggested improvements would include the following: a brick masonry base of sufficient height; the external application of waterproof mud plaster; and a suitable outlet for conveniently removing the grain.

Earthern pots. These structures are quite common in Bihar and other parts of the country and are used for storing small quantities of food grain indoors. These earthern pots are kept either above ground or underground. The structure is not moisture-proof, and the grain may be damaged by insects and fungus. In order to prevent the penetration of moisture inside the structure, two coats of bitumen paint applied externally have been found sufficient.

Oil drums. A slight modification is sufficient to convert an empty oil drum into a grain storage structure. The modification involves the provision of an airtight inlet and a lockable outlet.

The various types and salient features of structures and containers in use are indicated in table 2.

Storage in living rooms is most widely used in the Ludhiana District of the Punjab. All the marketable surplus is stored in this way, mainly because it is easy and convenient to do so. The use of mud bins is still prevalent among small farmers because of its low cost.

Grain kept longer than six months for household consumption is stored in metal or cement bins. Seed grains are stored in bags, but dried in *bhusa*.

Rural structures are in general not rodent-, moisture- and insect-proof. Their life is short and frequent maintenance is necessary. Losses are considerable.

The relative economics of different farm storage structures have been studied taking into account their life, initial investment costs and grain loss. Taking a 15-year period as the basis for comparison (the life of present structures varies from 1 to 15 years), the total investment involved in using a given type of structure was calculated.

Although the data provided by the ASCI indicate that improvised indigenous structures are more economical than metal bins, the inference may not be realistic. Experience at Hapur has shown that the average life of a metal bin may be over 20 years, in which case the relative economics will change in favour of metal bins.

In a study[6] conducted during the period 1968–1973, the Food and

[6]Farm and Community Grain Storage Development Projects in India, undertaken by FAO during 1968–1973.

TABLE 2. INDIGENOUS STORAGE STRUCTURES IN USE

Generic name for the group	*Salient features of the structures*	*Some other names in common use*
Mud bin	Unburnt clay mixed with straw, oval-, cylindrical- or chimney-shaped with small capacity of 2 quintals, life of 3–5 years	*Kothi, kuthla, bharola*
Pucca kothi	Brick masonry, rectangular, fixed capacity of 10–30 quintals, life of 10–15 years	*Pucca, bukhari, kotha, kanja*
Bamboo and straw structures	Wicker or plaited straw stalks, bamboos, date-palm leaves, mud and cow-dung mixture for base and plastering for walls, varying capacities and life-spans, fixed or portable	*Palla, dholi, gummi, gade, puri, kup*
Thekka	Gunny or cotton cloth, cylindrical or oblong shape, capacity of up to 80 quintals, indoor and portable	*Palli, hapur thekka*
Wooden structures	Rectangular, on raised platform, different capacities	*Kothar, arah*
Cement bins	Indoor, rectangular fixed, capacity of up to 30 quintals, life of 10 years	
Steel drums	Old tin containers, average capacity of 1.5 quintals	

Agriculture Organization of the United Nations (FAO) reviewed the development of improved storage bins and stated:

> "Attention was given to the use of metal because of ease of fabrication and hence assured quality of construction. It was subsequently realized that only 5 to 10 per cent of farmers could afford to pay for a structure even at a subsidized price. Later models were therefore designed to use indigenous local materials, including precast concrete rings."

The Government of India's Evaluation Committee felt in 1974 that it would be desirable to give more emphasis to improvements in existing practices instead of inventing new structures for which raw materials were not readily available. Non-metallic structures should be given priority.

In the Indian situation, while there is a great need to adopt modern storage structures, the need for improving existing structures is also imperative. A proper mix of the two approaches may involve appropriate technology for improving farm storage.

Government programmes to minimize farm losses

The upward trend in the production of food grains will continue to help farmers minimize post-harvest losses. The Department of Food launched a

"Save Grain Campaign" during 1965–1966 as a pilot project, and from 1969 to 1970 as a regular plan. IGSI at Hapur, Uttar Pradesh, and its field stations at Bapatla (Andhra Pradesh) and Ludhiana (Punjab) are engaged in R and D work. The objectives of IGSI include improved storage structures, co-ordination of all storage research, training in handling and storage, and orientation and review programmes.

Designs of various metallic, non-metallic, indoor, outdoor, underground and partly underground bins have been developed, as well as improvements of existing structures of simple design and the use of discarded coal-tar drums. In a collaborative programme, data have been collected on losses, regional insect distribution, field infestation and the quality of grain marketed.

Extension programmes are being carried out with the help of 11 offices in different parts of the country as part of the "Save Grain Campaign". Six more offices will soon start functioning. The aims are as follows:

(a) To train farmers, traders and extension officers in storage and preservation of grain;

(b) To extend scientific techniques through demonstration and publicity and develop model villages;

(c) To arrange credit facilities for farmers to buy improved storage structures;

(d) To maintain liaison with state governments and to arrange for a steady supply line of storage structures and pesticides.

Under the Save Grain Campaign, within the framework of the fifth five-year plan up to March 1978, 9,380 farmers have had stipendiary training programmes and 71,344 volunteers have had shorter courses. There have been 108,349 grain fumigations, 3,921,812 rat burrow fumigations, 293,166 domestic rodent control operations and 166,850 prophylactic treatments, in addition to 589 radio talks, 62 television programmes, 1,101 press reports, 783 exhibitions, 1,494 film shows, and 62,349 stencilled slogans. In addition, 60,390 leaflets containing advice have been given to farmers.

The designs developed at IGSI are in great demand in other developing countries. For the programmes of the "Save Grain Campaign", the United Nations Children's Fund (UNICEF) has contributed about Rs 50,000 lakhs, and the European Economic Community has agreed to grant up to 5,550 million units of accounts (Rs 54,500 lakhs) to finance the Intensive Grain Storage Project in India.

FAO organized a seminar on farm grain storage in which there were 14 participants from countries in eastern Asia and 10 observers from other countries.

The state governments of Andhra Pradesh, Haryana, Uttar Pradesh and West Bengal are being provided with financial assistance to set up their own Save Grain Campaign teams. In addition 100 Farmers Training Centres have been included in a programme to promote scientific storage. The Department of Food is meeting the cost of appointing a woman demonstrator at each centre to work in nearby villages in educating women, to train the instructional staff of the centres, and to supply pesticides and publicity equipment.

FOOD-GRAIN STORAGE BY PUBLIC AGENCIES

Public agencies are responsible for procurement, transportation, storage and distribution of grain, especially wheat and rice. Storage helps to regulate supply and prices. In the subcontinent, these functions are mainly performed by FCI, CWC, SWC, state governments and co-operatives.

After the creation of FCI in 1965 and its gradual take-over of all storage accommodation from the Government by 1969, public agencies constructed new facilities to meet the growing demand. FCI launched successive crash construction programmes and other agencies followed suit. However, the growth pattern and investments have not matched demand in the past decade or so. In the absence of adequate covered storage capacity, FCI resorted to large-scale open storage popularly known as cover and plinth (CAP). This type of storage, a new and cheap technique, was a landmark in technology developed by FCI.

Overall capacity provided by FCI, CWC and SWC increased fourfold within 12–13 years, from 25 lakh tonnes in 1965/66 to 97 lakh tonnes in 1977/78, but growth of the capacity of state governments or their agencies has been slow.

Only 60 per cent of the total storage capacities of CWC and SWC are utilized for grain.

Types of storage facilities

In India, food grains are handled, transported and stored in bags. Accordingly, the entire marketing and storage facilities are geared to the bag handling system alone. Bulk-storage facilities constitute a very small fraction of the total available in the public sector. Existing infrastructure facilities, cheap labour, marketing, handling, transportation and storage facilities have been factors inhibiting the adoption of modern or advanced technology of bulk storage. Though it has been realized that bulk storage in vertical silos has advantages, the system has not yet gained wide popularity. Only since the early 1970s has modern storage technology received some impetus through the setting-up of vertical reinforced concrete silos at selected centres.

Conventional godowns

The conventional godown is a rectangular rodent-proof structure known as a "flat warehouse" in Western terminology. The standard basic unit has a capacity of 5,000 t. Depot complexes are generally designed to conform to the configuration of the land area and the needs of road and rail inflows. Essentially for bag storage, they provide considerable flexibility for different grains and other commodities, and are accessible to any means of transport. All handling operations are manual.

The dimensions of a typical godown are 21.8 m × 127.6 m × 6.35 m. For a unit of 50,000 t capacity, each warehouse is divided by solid partitions into three equal compartments. The rated capacity is 5,000 t when bags are stacked 15 layers high. The design makes it weather-proof, gas-tight (for fumigation), rodent- and bird-proof, and impermeable to subsoil moisture. Provision is made for natural aeration.

The floor is designed for a peak load factor of quintal bags stacked 22 high. The height of the roof over the floor at the longitudinal walls is 18½ ft (15.6 m), and the standard stack height should be 16 ft (4.9 m) high, leaving a clearance of 4½ ft (1.4 m). Standard thickness of the wall is 13½ in. (34.3 cm), (1½ bricks in cement mortar in the proportion of 1:6) with cement plaster on either side, and the roof rests on reinforced concrete columns. The door opening is covered by rolling shutters and ventilation regulated by glaze shutters. Generally a platform on one side is adequate with the width restricted to 6 ft (1.8 m).

Bulk storage structures include steel silos, reinforced cement concrete circular and hexagonal bins, and reinforced cement-concrete vertical silos. Steel silos are now considered obsolete in view of their high requirements of scarce steel.

Reinforced cement-concrete circular bins

The circular bins have a capacity of around 4,000 t, are circular in shape, and are constructed on a platform 3½ ft (1.1 m) above the ground. The diameter is 77⅓ ft (23.6 m) and the side walls are 35 ft (10.7 m) high. The roof is domed and the flooring, also of reinforced cement-concrete, is laid to slope over 3 in. (75 mm) of lean concrete in the proportion of 1:5:10. A layer of 700-gauge polythene is sandwiched between the lean concrete and the sand filling underneath. Grain feeding is by hopper and pneumatic equipment, which can also be used for extraction. Aeration is through a duct and fumigation through ½ in. (12 mm) diameter pipes inserted at equal intervals on the periphery with stainless steel nozzles. Internal temperature can be recorded. Inherent limitations of slow receipt, dispatch and drying facilities make the bins unsuitable for high turnover.

Reinforced cement-concrete silos

The new vertical silos are similar to grain elevators in Western countries and are constructed of concrete reinforced with steel. Capacity is generally more than 10,000 t. A conical hopper bottom is 13⅓ ft (4.1 m) above the ground. For feeding from the top a hopper empties bags on to a conveyor belt. For reclamation a conveyor runs under the hoppers. Aeration is from the top by fans installed in the head house, and the air escapes through openings in the hopper bottom. The silos also have a temperature recording system. Improved types are being built in Punjab and Uttar Pradesh.

Compared to hopper bottom silos, the flat bottom-type has 25 per cent more capacity, with the disadvantage of slow emptying and hand cleaning. For high throughputs it would be feasible to use hopper-bottom vertical silos with built-in electrical and mechanical equipment for grain handling.

Vertical silos, recognized as the best form of bulk storage from the point of view of better aeration and faster handling, are quite expensive. They form part of the overall system and are not mutually exclusive of handling and transportation systems. These need to be adopted, if at all, only at strategic locations such as ports.

CAP

CAP or open-storage techniques were evolved by the FCI as a short-term measure for transit purposes in 1971–1972. They have all the essential features to meet urgent needs in arid and low-rainfall areas for all hardy and non-hygroscopic grains. CAP storage provides reasonable protection, but requires more care and effort to preserve stocks. The grain, largely wheat, is stored in bags on a brick plinth with wooden crates. Each unit can hold 1,500 bags 15 to 20 high, on an area of 20 ft × 30 ft (6.1 m × 9.1 m), covered with black polythene and tied with nylon ropes, to protect it against wind and storm.

Criteria for selection

The selection of appropriate storage technology for India is influenced by various factors and criteria, such as the following:

Bulk or bag handling

Period and purpose of storage and type of grain

Whether the facility is for various grain types or only one

Capital investment

Operating or recurring cost per tonne of grain handled

Storage worthiness, incidence of losses and preservation costs

Operating returns, savings achieved by curtailment of work-force

Demand time and construction period

Existing mix of facilities

Marketing, transportation and storage infrastructure, facilities and practices

Comparative economics of bag and bulk storage

Comparative economics of bag and bulk storage could broadly be discussed under the parameters of initial investment, construction period, suitability for storage, preservation costs, and operating costs and returns.

For the sake of clarity, the comparative costs of units or complexes of 50,000 t, with all infrastructural facilities such as railway sidings and ancillary buildings, will be considered. Estimates of initial capital construction costs per tonne inclusive of engineering services, supervision and contingencies, are as follows:

Type of facility	*Cost (dollars per tonne)*
Conventional godown complex	50
Bulk-storage, inland concrete silos	150
High-turnover port silos	300

For silos the figures include mechanical handling equipment. Matching infrastructure for bulk storage would also, however, require huge investments in India.

Estimated construction times are two years for a conventional godown complex, including six months as a preparatory period, and 3½–4 years for reinforced cement-concrete silos (6–12 months preparatory). Some godown units may become available during construction of a complex.

Suitability for storage and preservation costs are basic factors. Bulk storage, for example, is unsuitable for milled rice, some millets and pulses, for which bag storage is most appropriate. It is only for cereals and their milled products that bulk structures are suitable.

Technical opinion about bag storage in godowns is that grains can be kept satisfactorily up to two years under the most suitable dry climatic conditions. In coastal areas, however, the period varies between 8 and 12 months only. On the other hand, the shelf life of grain silos can be up to five years irrespective of location.[7]

Estimated losses are about 1 per cent per year in godowns and 0.2 per cent in bulk storage silos irrespective of the time involved. Thus losses and preservation costs are much lower in bulk storage structures, rotation problems can be avoided, and operational and handling costs reduced. In fact, advanced storage technology provides the answer which is technically most feasible, except for the huge capital investments required for both the structures and parallel facilities, and the need for drastic changes in the entire food-grains marketing and handling systems.

Operating costs, which vary substantially, are also important. Bulk-storage facilities are more capital–and less labour-intensive, while conventional facilities are less capital–and more labour-intensive. It might appear that operating costs would be less with godowns, given their labour requirements. But the operational economies of larger throughput with less handling costs and smaller storage losses coupled with less preservation costs reduce the unit costs considerably with each additional turnover in silos, where handling capacity is high and there might be more than one turnover.

Some advantages of the integrated system are quicker handling, freedom from rodents and insects, easy aeration and fumigation and greater usable area. Bulk movement becomes cheaper, quicker and safer. More importantly, the grain can be stored for three to five years. Though initial costs are high, the operational cost is lower.

It is particularly in the context of the country's shift from an era dominated by scarcities and imports to an era of surplus production and consequent increase in the volume of transactions and stocks that the need for advanced storage technology has been realized. Overall storage gaps have been estimated at not less than 3–4 million tonnes.

Shifting to advanced storage technology

Advanced storage technology does have some disadvantages that will slow down the shift from traditional technology. These include adverse effects on

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[7]S. V. Pingale, ed., *Handling and Storage of Food Grains* (New Delhi, ICAR Publications, 1976).

employment, possible underutilization of capacity, and large initial investments. As large-scale or collective farms are rare in India, the economies of large-scale operations through bulk storage may not be possible. When the peak marketing periods of some crops are concentrated over two to three months, use of the facilities during slack periods may not be economical. A shortage of high-level operating skills or construction materials and longer construction time could also hamper a switchover. It has therefore been considered appropriate that the transformation be introduced gradually.

A few silo and bin structures have been installed experimentally and bulk storage capacity of 383,000 tonnes exists at 12 centres. Moreover, a programme for additional installations has been initiated with the financial assistance of the World Bank. Under this project, five silos each with a capacity of 20,000 t, are being constructed in Punjab and Uttar Pradesh. Bulk transportation is an essential element in an integrated system of grain procurement and bulk storage and its distribution in bulk or bag. To provide a link between producing area silos and distribution silos, and to facilitate operation of an integrated system, a pilot project is coming into operation under the World Bank Assistance Programme. The proposed facilities would eliminate the need for bagging grain for transfer to the centres. Alternatively, farmers may deliver direct to the procurement centres. Here the grain would be graded, weighed and conveyed into elevator steel hopper bins to be kept in bulk until carried to storage points. The pilot project also foresees provision of carriers to move the grain from market yards to the rail-head terminal. Improvisation of flat bulk railway wagons and the provision of special train wagons have also been envisaged.

The construction of two more high-turnover silos in the port areas of Madras (25,000 t capacity) and Haldia (50,000 t) has been taken up.

Bulk-cum-bag storage structures at about 20 centres are also being built for the first time in the country. Such structures could appropriately be described as intermediate storage technology, incorporating both traditional and advanced characteristics.

Unless introduced in phases, advanced storage technology, though widely adopted in developed countries, would not be entirely appropriate to present Indian conditions. It would therefore be useful to consider a *via media* providing the advantages of advanced storage technology without having to invest so much in silos and infrastructure. Such an approach involves an ideal combination of conventional and advanced storage technology, with basically wide-span structures to hold substantial quantities of grain in bulk. Initially used for bags, the capacity for bulk storage will be much greater. Mechanical handling could be incorporated later, only the warehouse portion is first needed.

Since considerable progress has already been made towards developing bulk handling and transportation facilities in major states holding surplus grain it may be appropriate to adopt intermediate storage technology in the form of bulk-cum-bag storage structures, with the provision of complete mechanical handling facilities. Arrangements for aeration, fumigation of grain, temperature detection etc. could be based on successful experiences in Australia over two decades. Steps have already been taken to set up bulk-cum-bag structures at 20 Indian locations under the World Bank Assistance Programme.

The storage gap identified today is primarily due to the increased storage requirements for buffer stocks. Planning for the future should take into account not only the choice of storage techniques, but also economies of scale flowing from godowns or complexes of different capacity. Large-size units or complexes are suggested, depending upon requirements from region to region.

The food industry in India

Central Food Technological Research Institute, Mysore, India

BACKGROUND

Over 50 per cent of India's gross national product (GNP) is derived from agricultural and allied activities. Development of agriculture has therefore always received priority in the five-year plans. One of the most promising avenues of employment is the development of agro-based industries using economically sound, labour-intensive and capital-saving technologies with low energy levels to manufacture products of required quality. These industries, in addition to providing employment to a large number of persons, have the following advantages:

(*a*) Processing adds considerable value to a raw commodity;

(*b*) Stable prices for farmers stimulate agricultural production;

(*c*) Qualitative and quantitative losses are reduced;

(*d*) In the growing producing areas agro-industries may increase opportunities for rural populations, thereby reversing the undesirable trend of urban migration;

(*e*) Exports of processed products instead of raw materials will increase foreign-exchange earnings;

(*f*) Development of other industries can be stimulated.

A systematic, socio-economically oriented research effort is required to develop relevant technologies. A beginning was made in India almost three decades ago, and today most agriculturally based industries in India are using indigenously developed technologies.

In 1951, the Industries Development and Regulation Act was passed; its main purpose was to prevent haphazard growth of the food-processing industry. However, the first two five-year plans laid more emphasis on the development of heavy rather than consumer-goods industries. Only the fuller utilization of the existing capacities in agro-based industries was considered essential. During the third plan period more emphasis was laid on development of agro-based industries on a par with development of agriculture. Therefore, food industries made significant progress only during the last decade, but they now occupy an important place in the national economy.

According to industrial surveys, food ranks second to textiles with an output valued at more than Rs 1,750 million, and claims 17 per cent of the total gross industrial output. Food industries employ 10.92 per cent of the total labour force in 18 groups covering more than 80 per cent of all industrial output. If the output of rural and small industries like rice, flour and oil milling were also included, the value of the output would go even higher. The capital invested in small units probably amounts to millions of rupees, and the labour force employed is probably several million.

Industries based on agricultural raw materials have a weighted value of about 45 per cent in the index of industrial production. Food industries comprise all aspects of production, processing and storage, including units in village and small-scale industries in both unorganized and organized sectors. As distinguished from modern small-scale units, cottage and household units are mostly in rural and semi-urban areas. They involve relatively lower levels of investment and technology and provide largely part-time employment. The non-factory unorganized sector accounts for 5 per cent of the GNP and 10 per cent of the labour force in India, but inadequate statistics handicap an assessment of development.

The emergence of small-scale industries is a significant phenomenon. A recent survey showed 7,108 food-processing units with an installed capacity of Rs 2,445 million and a total output value of Rs 1,569 million (see annex, table 1). They employ more than than 140,000 workers, about 8.3 per cent of the total in the small-scale sector. Their products include meats, fruits and vegetables, breads and pastries, cocoa, sugar, confectionery, cashews, starch and animal feed.

Food industries in the organized sector can be classified as follows:

(a) Basic industries, including cereals, pulses, milling and cane processing (see annex, table 2);

(b) Other industries, including meats, fish, fruits and vegetables, breads and pastries, confectionery, breakfast foods, dairy products, baby foods, starch and derivatives and malt (see annex, table 3).

Because they are basic necessities, the processing of food grains, oil-seeds, sugar and *gur* (raw lump sugar) have been well established, and modern developments have brought continuous improvement in product quality and yields.

During the last two decades, India has become an exporter of processed food products instead of a net importer. The contribution was only 16 per cent in 1965/66, but increased to 28 per cent in 1975/76 (see annex, table 4).

FOOD PROCESSING IN INDIA

Food grains

Annual production of rice, wheat, coarse grains and legumes is nearly 120 million tonnes. Of this, 15–35 per cent goes from the villages to urban areas. The rest is used in the villages themselves. The main processing operation consists in milling into dhal (decorticated split pulse) or flour. In certain areas puffing, parching or flaking of some cereals for local use is also practised.

With the introduction of electrically operated machines into villages, hand-grinding or hand-pounding practices are diminishing. Hand pounding of paddy is, however, still favoured where electric or diesel power is not available and because of the employment opportunities provided.

Out of a total production of about 45 million tonnes of rice, 15 to 20 million tonnes enter the commercial channel for marketing and processing in about 8,000 mills with capacities of between 1 and 4 t/h. Modernization of the commercially organized sector of milling is enforced as government policy. In the rural sector about 30 million tonnes of paddy are processed into rice for local consumption. For milling there are about 70,000 single-unit huller machines.

Research and development (R and D) efforts to improve rural efficiency have received considerable attention. Low capacity mini rice mills could be of great use for the villager. Several versions have been envisaged, and some are in commercial production. Incentives are needed to popularize their use.

Parboiling of paddy prior to milling is still practised in the household by many farmers and by labourers in the villages, where simplified procedures and equipment need to be developed. Production of flaked rice, practised as a cottage scale-industry in towns and cities, should be undertaken in villages, as it requires little skill or capital and can provide employment. Similarly, units for producing puffed paddy or puffed rice should also be set up in villages.

Wheat is consumed mainly in the form of whole-meal *atta* (flour). Power-operated plate, emery or hammer-type grinders are used, but hand grinding may still be practised where power is not available. The provision of a sieving facility in the unit would be advantageous, as the whole-meal *atta* is normally sieved to remove coarse bran before consumption. Sieving immediately after grinding would also help in mobilizing bran resources for feed and other uses. Production of semolina from hard wheat is a small-scale industry becoming popular particularly in areas of durum wheat production. Such units should be popularized, because they can produce semi-refined semolina or *dhalia* (coarsely ground grits) for local consumption. Partial removal of the bran prior to coarse grinding and suitable product grading would help to promote this small-scale cottage industry.

About 25–30 million tonnes of coarse grains such as sorghum, maize, bajra (*Pennisetum* millet) and ragee (finger millet) are produced, particularly in low rainfall regions or irrigated areas where relay cropping is practised. Most are ground into whole-meal flour, sieved to remove bran and used for making unleavened cakes or soft cooked dumplings. Dehusking before grinding would help in the production of semi-refined flours, in making newer varieties of food products and in extending supplies of rice and wheat. Technology and machines for removal of the husk, bran etc. have been developed and utilization at the village level is expected. The emphasis is on low-capacity machines to produce flour and semolina for local use.

About 10 million tonnes of pulses are produced. Most are used after dehusking and splitting. Pulse milling has become a commercially important industry. Traditional pre-processing by wetting and sun-drying is time-consuming, depends on the weather, and entails losses. Recent research has led to the development of technology which drastically reduces processing time and increases the yield of pulses, and a new mill has been designed. Further study is still required.

The milling by-products of all cereal grains that would be available through setting up rural grain processing industries could lead to local production of compounded animal feeds for dairy, poultry or even draught animals. Advances have been made in grain processing and utilization. Indigenous or foreign-developed technologies used by the organized sector should be adopted and if necessary modified to suit rural requirements.

Fruits and vegetables

Since the Second World War, when factories were established to meet defence needs, the fruit and vegetable processing industry has grown slowly. There are now about 1,000 units in various parts of the country. The major products are from tropical fruits such as mangoes and pineapples in the form of pulp, juice, slices, pickles and chutneys. India produces about 32 million tonnes of tropical and subtropical fruits and vegetables. For a variety of reasons, such as year-round availability, dieting habits and socio-economic conditions, only about 1 per cent is processed. Out of 55,000 t processed recently about 15,000 t were exported, 10,000 t utilized by defence personnel, 10,000 t taken up by catering establishments, and only 20,000 t consumed in households, mostly in the higher income group. Low domestic consumption has considerably hampered growth of this industry.

Processing of fruits and vegetables can be classified into two categories. One, producing products such as jam, jellies, juices, squash and ketchup, can be called the modern sector, and the other, producing pickles, chutneys and dehydrated fruits and vegetables, the traditional sector. The former is capital-intensive and well organized whereas the latter is spread over the country, including rural areas, and affords scope for modification.

Modern sector units produce quality products and are mostly located in urban centres. About 20 of them account for more than 80 per cent of the products. Production is designed mostly for export and to meet the demand of the defence forces. Since there is no strong expanding internal market, considerable capacity is unutilized. High production costs include about 30 per cent for raw-material prices, whereas sugar accounts for about 16 per cent and packaging materials about 30 per cent. Exports, mostly to the Middle East and Eastern Europe, register annual growth.

Traditional processed fruits and vegetables, popular throughout the country, are mostly in the form of preserves, chutneys (sweet) and pickles (spiced). Home-dried vegetables are used in many households. Recipes vary according to local tastes, and many households have traditional specialities. With the slow movement of rural population towards the cities and the emergence of working women, the need for organized production has been felt and is being encouraged.

India produces, usually to order, most of the plant and machinery required for its fruits and vegetable processing. Tin plate required for cans is at present imported, but R and D has raised prospects that the imports will soon be replaced by locally produced material. Some states have begun setting up agro-industrial complexes to bring an integrated approach towards production, processing and marketing. Consideration is being given to a division of operations so that fruits can be processed at the growing centre into pulp, purée or concentrates, and then transported to the consuming centres for further processing into the final packed products. These methods utilize locally available raw materials, ensure good returns to the growers and increase employment opportunities in the regions. International agencies such as the World Bank also contribute towards this. An apple processing plant has been set up with World Bank assistance in the northern part of the country in Himachal Pradesh. With the co-operation of the Government of Bulgaria, tomato and pineapple processing complexes are being envisaged in Karnataka in southern, and Bihar in northern India

Dairy industry

Dairying in India, basically a rural agricultural enterprise of millions of small farmers, received a fillip with the industrialization that took place following independence. Public awakening warranted the establishment of organized milk collection, processing and distribution of milk to cater to the needs of expanding urban areas. During successive five-year plans, stress was laid on different facets of dairy development. The National Dairy Research Institute was enlarged. The National Dairy Development Board under the Ministry of Agriculture, was established in 1965 to speed up dairy development. Objectives included production, milk procurement, processing, distribution, and technical and engineering services. In 1970, the Government set up the Indian Dairy Corporation as a corollary to the India World Programme Project. State Dairy Development Corporations were set up to promote development. The Planning Commission and the National Commission on Agriculture have calculated the importance of co-operatives, and the success of the Kaira Co-operative Milk Producers Union (KCMPU) at Anand, started in 1948, provided impetus for development, including perhaps the biggest project of its kind in any country, known as Operation Flood, which was launched in 1970. One important programme was the organization of rural milk production through co-operatives to supply large plants in cities.

Operation Flood II was initiated in July 1978 as part of the sixth plan, with a massive outlay of Rs 483 million. It envisages the formation of 25 cluster federations involving 10 million milk producers and the achievement of self-sufficiency through a well-developed, modern dairy industry.

Starting from 10 million t/a in the pre-independence period, India now produces 26 million t/a of milk. The National Commission on Agriculture has projected a demand of 44.17 million tonnes for 1985, while for adequate and economic supplies to all major cities a national milk grid has been envisaged. At present, there are 77 liquid milk plants, including those at Bombay, Calcutta, Delhi and Madras, seven product factories, three creameries, and 43 pilot schemes, all in the public sector, with a total throughput of about 2.25 million litres.

Institutional arrangements are necessary to receive and transport the milk from primary producers for processing. The KCMPU, Anand, maintains a collection centre and trained staff in each co-operative. Transport contractors arrange to collect from the villages and deliver to the factory. The 780 societies are divided into 82 groups or transport routes and the union bears the cost.

The private sector has also been encouraged to set up factories in potential milk-producing areas as part of the effort to make the country self-sufficient in respect of products such as butter, milk powder, condensed milk, infants' milk and malted milk. India is almost self-reliant in the production of table butter, condensed milk, infants' milk and malted milk. Other indigenous products from milk are *khoa* (cheese), ghee (butter oil) and *dahi* (curd).

The present utilization of milk is as follows: unprocessed milk, 45 per cent; ghee 33 per cent; butter, 6 per cent; *dahi*, 8 per cent; *khoa*, 5 per cent; and other products, 3 per cent. Annual production figures are as follows: baby food, 26,000 t; milk powder (whole and skimmed), 18,000 t; condensed milk, 5,000 t; malted milk, 15,000 t; and table butter, 15,000 t.

India manufactures a complete range of equipment for handling, processing and manufacture. Three large-scale, and many small-scale, units can together supply diverse equipment.

The percentages of milk adulteration vary from region to region and may even be as high as 80 per cent. It is also common in milk products. To ensure pure and wholesome products for children, the Government of India has provided for minimum standards under the Prevention of Food Adulteration Act, 1954, and rules laid down in 1955. Since the composition of milk varies from region to region, standards are established on a regional basis. The Indian Standards Institution (ISI) has laid down more than 41 standards for products, and has also standardized types of equipment, including glass bottles and rail tankers. ISI has also drawn up guidelines on cleaning and sterilizing cattle, and on cattle feeds and housing. Ghee is graded under the Agriculture Produce (Grading and Marketing) Act, 1937. The Directorate of Marketing and Inspection has a network of laboratories to analyse samples of products graded under AGMARK, a voluntary system which has helped to improve products and quality.

India's dairy industry has advanced considerably during the last 30 years. In implementing its programmes, the interests of primary producers and the rural economy have been the guiding factors. Urban markets developed through the distribution of quality milk by the public sector have helped to increase production. A chain has been developed for the movement of milk from the primary producer to processing establishments and ultimately to the consumers. India has now become self-sufficient in many dairy products. Yet there is still a wide gap between requirements and the availability of milk, calling for an even more aggressive programme.

Meat products

The livestock population of India totals approximately 348 million, consisting of 50 per cent cattle, 15.8 per cent buffalo, 12.4 per cent sheep, 19.7 per cent goat and 1.4 per cent pigs. Of these, 0.5 per cent of the cattle, 1.5 per cent of the buffalo, 29 per cent of the sheep, 42 per cent of the goats, and 33 per cent of the pigs are slaughtered annually for meat. Slaughter of buffaloes is increasing because of the demand for this meat from countries of the Middle East. Most of the meat is sold fresh and only a small portion is processed. The average *per capita* meat consumption by Indians is 14 grams per day, as compared with the generally recommended amount of 34 grams. Demand will, however, increase as the economic status of consumers improves. Availability of meat could be increased by better animal husbandry, such as breeding animals for meat. Ham, bacon, sausages and other products, including canned curried meat, are produced for defence and civilian requirements. Techniques have been developed for ensuring suitable tastes and flavours of indigenous meat preparations, concentrated meat gravies, strained baby foods and meat tenderizers, and also for curing ham and bacon. Some of these have export potential. The primary requirement for this sector is the modernization of slaughter houses. Regional bacon factories producing cured pork products have facilities for slaughter and dressing. A modern abattoir is in operation in the Bombay area, and more are being set up elsewhere, all equipped to recover and utilize all by-products.

For a breakthrough in the export of meat and meat products, concerted efforts have to be made to raise livestock of the required quality in selected zones free of diseases such as foot-and-mouth disease. Kenya, for example, has increased its exports by establishing disease-free zones. This is essentially an activity for which underemployed village labour should be used. The Small Farmer's Development Agency and similar bodies could be entrusted with the task. State governments in India have started work in this direction.

Fish products

India, with a coastline of about 4,000 km, has an annual catch of about 2.3 million tonnes of fish, and exports of fish products totalled about Rs 180 million in 1976. India is now a leader in processing and exporting shrimps. Frozen prawns valued at Rs 160 million were exported during 1976, and are the main reason for the expansion of exports of marine products. Considerable and quick increases could be achieved in the overall availability of prawns and other fish by developing inland fish culture, with which some success has already been registered. There are large catches of sardines and mackerel, but landing centres are not yet adequately equipped for handling and storage. As a result, a significant percentage is lost before reaching markets and processing factories. Measures to chill fresh fish are urgently needed.

Canning

At present canning is mainly for sardines and tuna in oil and shrimp in brine. In the Indian Ocean, tuna and mackerel are the most important of the fish caught and sardines with oil could be profitable when canned both for internal and foreign markets. Aluminium should be introduced as material for cans since the metal is indigenously available and does not react with the food, and cans made from this metal are easier to open.

Development of new products from inexpensive varieties of fish could be accelerated by freezing grainy or shredded meat into blocks.

Salting and drying

A substantial percentage of fish is at present salted and cured by crude and primitive methods which should be more scientific in order to achieve more efficient results. Pickling with salt, vinegar, sugar and spices is also widely employed, and the preparation of new high-quality products, such as marinated herring, is another line of work to follow.

Fish meal and by-products

Fish meal is a principal ingredient of poultry feed, but processing in India is still mostly carried out as a cottage industry and should be mechanized to obtain better quality.

The entrails of fish and prawns are sources of biochemical and pharmaceutical products and should be profitably utilized. Using the waste from freezing, canning and curing can improve the economics of plant operation. Information should be disseminated on the potential of by-products and use of wastes. Chitosan and bacto-peptone from squilla and shrimp waste have many industrial applications, while seaweeds yielding agar, algin and carrageen are abundant.

Poultry and poultry products

The value of poultry production has been estimated at Rs 5,600 million for 1979. Feed costs more than half of the total expenditure on raising poultry. Cattle and poultry feeds are produced by a number of plants in the public sector and by small-scale manufacturers. In 1974, there were about 33 manufacturing units in the organized sector, and 23 have formed a Compound Livestock Food Manufacturer's Association, which in 1979 had an estimated production of approximately 3 million tonnes of poultry feed and 4 million tonnes of cattle feed.

With a well developed and expanding poultry industry, the processing of eggs for egg powder and albumen flakes seems promising, particularly the latter. Egg yolk as a by-product could be useful for tanning leather, while the shell finds uses in a number of industries.

Inadequate refrigeration causes the loss of large quantities of eggs, though when preserved with coating oil they can be stored at ambient temperature for a longer time. Culled chicken meat is tough in texture, but chicken sticks, sandwich spread, sausages and chicken soups have been successfully prepared. Canned chicken *biriyani*, curried chicken etc. offer good scope for export to the Middle East. Raising chickens for human consumption is a new trend emerging in the industry. Five crops of broilers can be raised in a year, and the efficiency of production has resulted in a comparatively cheaper price. Cockerels, usually destroyed in millions every year, could be made suitable for human consumption, by giving them cheaper feeds. A method of curing and smoking has been developed for dressed poultry, allowing storage at ambient temperature for about a week with minimum loss of flavour and lustre. In addition, conditions have been standardized for processing superior quality *tandoori* chicken. Ingredients for imparting taste and flavour could be marketed ready to mix.

High standards of personal hygiene, plant sanitation and control measures are essential. ISI, the Export Inspection Agency and the Meat Products Order have formulated standards for the raw material and processed products to ensure against health hazards.

Plantation products

Indian plantation products (for example spices, coffee, tea and cashew nuts) are a major source of foreign exchange. Commercial crops of tropical spices, such as pepper and cardamom, are produced in southern regions, and those of temperate spices (celery and fennel) in the northern regions. Cured dried spices are marketed locally and also exported. Exports have to meet AGMARK specifications. Higher production costs and inadequate quality control has meant some loss of ground in foreign markets to competitors. Unsatisfactory cultivation conditions, failure of rains, increased labour costs etc. have been responsible for the abnormal increase in production costs. Some diseases have affected quality. Attempts are being made to remedy the defects by intensive scientific cultivation and production of disease-free and high-yielding plant strains by hybridization and mutation techniques.

Drying methods

Improved processing methods will be reflected in the quality of products. Sun-drying can bring contamination, variation in flavours etc. The natural convection of forced draft dryers helps to overcome such problems, as well as those relating to dependence on the weather. Pneumatic cleaners, vibrating graders and destoners based on air classification and vibratory conveyance on inclined decks used by some exporters produce clean, high-grade spices suitable for direct grinding or extraction. Use of air-cooled or jacketed, water-cooled fixed beaters, and double-roller or cage-and-hammer mills for grinding to avoid flavour loss from excessive heating is being implemented gradually, especially in making curry powders.

Concentrated spice oils and oleo-resins have a good export market abroad for use in food processing. The know-how has been developed as a result of recent research and is available to industry. At least two big firms are producing and exporting sizeable quantities. A dehdydrated green pepper which reconstitutes easily in hot water has been developed recently and has found a good market in Europe.

Tea, coffee and nuts

India annually produces about 450,000 t of tea, and exports some 207,000 t, mostly in the form of fermented and dried black tea. Processes for making hot- and cold-water-soluble instant teas from green leaf and instant green tea from green leaf have been developed indigenously, mainly for export. One commercial unit is already functioning.

India annually produces about 90,000 t and exports some 45,000 t of plantation and cherry coffee. *Arabica* and *robusta* coffee are the chief varieties, and standard methods of fermentation and curing are used. Processes for the manufacture of soluble coffee, coffee concentrates and ready-mix coffee beverages have been developed. The soluble coffee process consists of preparing a strong brew, concentrating it under vacuum and drying the concentrate.

India imports about 1,000 t of cocoa beans annually. Efforts to promote production within the country have been successful to the extent that all national requirements may soon be met. Cocoa powder, drinking chocolate and milk chocolate are in production.

India produces 235,000 t of the total annual world production of 650,000 t of raw cashew nuts, roasted, deshelled and with the kernels dried. About 60,000 t of the kernels are exported. Cashew-shell liquor is a by-product. Many units are functioning in south-western coastal areas. While roasting and drying are mechanical, deshelling is mostly manual to avoid too many broken kernels.

QUALITY CONTROL

Ensuring food quality standards is the responsibility of several government departments, which have established voluntary and mandatory specification requirements under the following enactments:

Act or order	*Operating authority*
Agriculture Produce (Grading and Marking) Act, 1937	Directorate of Marketing and Inspection (Ministry of Agriculture and Irrigation)
Prevention of Food Adulteration Act, 1954, and Rules, 1955	Directorate General of Health Services (Ministry of Health)
Fruit Products Order, 1955	Food and Nutrition Board (Ministry of Agriculture and Irrigation)
Sugar (Control) Order, 1966	Directorate of Sugar (Ministry of Agriculture and Irrigation)
Technical Standardization Committee, 1944	Army Purchase Organization, Department of Food, Ministry of Agriculture and Irrigation
Vanaspati (Control) Order, 1975	Directorate of Vanaspati (Ministry of Civil Supplies and Co-operation)
Meat Food Products Order, 1975	Directorate of Marketing and Inspection (Ministry of Agriculture and Irrigation)
Export (Quality Control and Inspection) Act, 1963, and Rules, 1964	Export Inspection Council of India (Ministry of Commerce)
Indian Standards Institution	Indian Standards Institution, Department of Industrial Development (Ministry of Industry)

The role and operational system of some of the acts referred to above are summarized below.

Agriculture Produce (Grading and Marking) Act, 1937. This Act is administered by the Directorate of Marketing and Inspection with the Agricultural Marketing Adviser as Chairman. Grading standards on raw agricultural produce were brought out by the Directorate, applying *inter alia* to ghee, butter, spices, essential oils and vegetable oils. A certification scheme for products is operated for the protection of consumers. Any organization or packer wishing to use AGMARK has to apply for permission, which is granted after the authorities are satisfied about the facilities. Use of the AGMARK symbol is then allowed. Most foods for export are required to bear the AGMARK symbol to indicate that quality standards have been met.

Prevention of Food Adulteration Act, 1954, and Rules, 1955. Prior to the enactment of the 1954 Act, most states had their own laws on food adulteration. Their variations were not conducive to free inter-state trade. The Act of 1954 has laid down general principles, giving the Government powers to frame rules which can be adapted to meet changes caused by developments in technology. The Act defines adulteration, food, misbranding, sale, food health authorities and other relevant terms. It empowers the Government of India to specify the qualifications, authority and duties of public analysts and food inspectors, and lays down sampling procedures. The Act also empowers a purchaser to act as a food inspector for the purposes of taking a sample and getting it analysed. During 1964, an amendment enjoined the manufacturers, distributors or dealers to give a warranty of quality to the retailer which can safeguard them later in the event of the food being found adulterated. Penalties for various offences and enforcement powers are prescribed. The Government is empowered to make rules on the following matters: defining standards of quality; control over production, distribution and sale of food; restricting packaging and labelling; defining conditions of sale or licensing; prescribing additives; and exemptions.

The Act provides that a Central Committee for Food Standards should include representatives from all states, the medical profession, ISI and consumer associations, as well as food technology and nutrition experts, agriculturists etc. The Committee can advise the Government of India and state governments in the administration of the Act, whether technical or otherwise. Expert sub-committees deal with specialized subjects.

Under the Act, four government central food laboratories have been established at Calcutta, Ghaziabad, Poona and Mysore to analyse appeals from the courts.

The opinion of the Director is considered final. Food imports are subject to inspection by port health authorities, who can send samples for testing.

The Rules of 1955 detail the qualifications, duties and functions of public analysts, food inspectors, central food laboratories etc. as well as methods of taking samples and procedures for sending them to the public analyst or the central food laboratory. Food colouring anti-oxidants, preservatives, emulsifiers and other food additives are also regulated, and tolerances are set for contaminants, pesticide residues and other pollutants. Specifications for the identity and purity of various foods have been laid down.

Enforcement of the 1954 Act is by and large in the hands of local authorities, and few state governments have separate enforcement machinery. Local bodies have not been very effective in controlling food adulteration. They have appointed sanitary inspectors to the dual role of food inspectors and performance has not been satisfactory.

One of the most important factors for implementation of food laws is the need for well equipped laboratories with qualified and trained technical staff. There are approximately 85 food laboratories in the country at district, regional or state level with about a third of them under local administrative control and the rest controlled by state governments. Most laboratories need sophisticated techniques such as gas chromatography, spectrophotometry, and atomic absorption spectrophotometry. The Government of India keeps in view the need both to develop such laboratories and to strengthen the analytical facilities, and provides financial assistance to some of the state or local bodies to purchase equipment.

Indian Standards Institution (ISI). ISI, as constituted by Act of Parliament, deals with the standardization of various articles, including food. The Agriculture Food Division Council (AFDC) deals with standards of foods and prepares national specifications in consultation with experts. Formulation of standards at the national level for quality requirements of food is entrusted to a series of committees under the AFDC. The ISI certification scheme is voluntary, and use of the certification mark on products requires approval by the authorities, who ensure that the manufacturers have the necessary technical know-how, hygienic conditions and essential facilities. Random sampling of products bearing the certification is carried out by ISI inspectors. Coal-tar colours permitted in some foods must be sold under the ISI certification mark.

TECHNOLOGIES AND THEIR AVAILABILITY

The national policy from 1950 of encouraging the development of indigenous technology progressively reduced dependence in the food industry on imported know-how and machinery. Today India is practically self-sufficient in almost all requirements both of technology and machinery (see annex, table 5). Some activities and products for which full-scale technology is available include the milling of rice, pulse, maize, oil-seed and flour, the solvent extraction process, fruit and vegetable products, spice processing, spice oils and oleo-resins, meat, fish and poultry-based products, alcoholic and non-alcoholic beverages, food enzymes, coffee, tea and cocoa processing, nut-based products, baby foods, protein-rich products, bakery goods, insecticides and pesticides, packaging etc. (see annex, table 5).

RESEARCH AND DEVELOPMENT INPUTS

Investment on R and D calculated as a percentage of GNP works out in India to less than 0.3 per cent, while developed countries spend as much as 1 per cent. As most small-scale units are in no financial position to undertake programmes on their own, it becomes the prime responsibility of the Government to bridge the gap. Investment on R and D, even though not producing direct returns, has a multipler effect and will be reflected eventually in the generation of income and employment. However, the Government could consider a small levy on the industry for development work. This might lead to a better appreciation of the work of R and D agencies and bring a continuous interaction between the industry and development organizations.

Indigenous research has created a reservoir of technologies to be exploited by entrepreneurs and industrial development organizations. A complete range of know-how exists for the manufacture of a variety of food products, and the use of agricultural by-products and food machinery. India can today even make turnkey offers for plants. Indigenous expertise is also available in quality control, standardization and packaging of food products.

NATIONAL AND REGIONAL POLICIES FOR FOOD INDUSTRIES

Generation of employment is one of the principal goals, and a necessary means, of development. There is an urgent need to choose the right pattern of development and create appropriate supporting institutions and infrastructure. The aim should be to lessen the widening disparities between classes of the rural population, regions, and rural and urban areas, and to achieve a higher rate of growth in rural incomes. Accordingly, government policy must be to force the pace of development in rural and urban areas by creating productive employment and facilitating better income distribution. The food industries can play a pivotal part in the efforts to achieve this aim.

Diversification of the rural economy intimately linked with agricultural development appears to be the soundest means of diversifying employment and relieving the pressure of a huge labour force unsuccessfully seeking to draw its sustenance from agriculture. Oil extraction, fruit and vegetable processing, sugar and confectionery, dairying, processing minor forest produce and milling cereals, millets and pulses are examples of food industries which can conveniently be located in the rural areas. Developing, improving and sustaining traditional rural activities of producing food materials and products also represent important elements in the policy package for the rural areas. The development of these industries, however, demands an improvement in their technology. The development of new industries with markets located primarily in the rural areas, while creating opportunities for local employment, will also promote local entrepreneurial skills. As in Punjab, the new industries will lead to the growth of various servicing industries.

Processing and marketing facilities, at present concentrated in urban areas, operate to the detriment of the rural sector. Because of the imperfect and monopolistic nature of the marketing services, the benefit of the price spread between the rural producers and the ultimate consumers is mostly appropriated through the urban market mechanism. As a matter of social justice, this aspect should therefore be examined carefully and efforts made to shift the benefit to the rural areas. This is possible if processing and marketing are undertaken in rural areas themselves. It will be necessary for the Government to develop an infrastructure to promote the growth of rural food industries.

The main objectives of the new five-year plan (1978–1983) are the removal of unemployment and significant underemployment, improvement of the living standards of the poorest strata of the population, and provision of some of the basic needs of the people by the Government.

The following policy guidelines have been laid down:

(a) Special attention will be given to small-scale industrial units in the "tiny" sector, that is, those with investment in machinery and equipment up to Rs 100,000 in towns with a population of less than 50,000 and in villages;

(b) Legislation will be introduced to protect cottage and household industries providing self-employment;

(c) Financial assistance will be extended to tiny units and cottage-scale industries;

(d) There will be an annual review of items reserved for the small-scale sector to ensure production efficiency;

(e) District service centres will be established to help small-scale and cottage industries during the new plan period. These centres will provide assistance to entrepreneurs in the form of data relating to raw materials and resources, machinery and equipment, availability of credit facilities, marketing and quality control;

(f) A separate wing in the Industrial Development Bank of India will be established to deal with the finances of small, village and cottage industries, and to co-ordinate and monitor credit facilities offered by other government institutions;

(g) Support will be given for standardization, quality control and market services for items manufactured in the small-scale sector. Purchasing preference will be given by government departments and public sector undertakings to products made in the small-scale sector;

(h) Simple measures or devices will be developed for improving productivity in the small-scale sector.

Development of indigenous technology through R and D will be promoted. The best available technologies in high priority areas will be purchased (where indigenous expertise is not available) for ultimate adaptation to the country's need. Foreign investment for industrial development will be allowed only on the basis of national interest.

Licences will not be given to start industries within certain limits of large metropolitan cities having a population of more than 1 million and in urban areas with a population of more than 500,000. State governments and financial institutions will be requested not to permit in these areas new industries which do not require licences. The Government will also assist large industries desiring to shift to approved locations in industrially underdeveloped areas.

Incentives will be given by the Government and facilities offered by the state governments to ensure balanced regional development. Special tax rebates for industries in underdeveloped areas and promotion of medium-level entrepreneurs for fuller utilization of capacities in certain agro-based industries are two such incentives. In achieving a sustained growth, constraints on development cause disparate growth in output and income among different regions. Motivational factors also play an important part in the use of all state facilities, and development of the food industries will not take place unless the population is adequately motivated to take advantage of the stat facilities.

Annex

DATA ON THE FOOD INDUSTRY IN INDIA

The following tables give information on the number and size of small-scale units, the dimensions of the agro-based industries, the processing industries, exports of processed food, and indigenous processing technologies available in India.

TABLE 1. SMALL-SCALE UNITS IN THE FOOD INDUSTRY

Sector	*Number of units*	*Installed capacity (millions of t a)*	*Production (millions of t a)*	*Fixed capital (millions of rupees)*	*Number of persons employed*
Meat products	6	3.9	7.8	9.7	91
Dairy products	277	45.9	23.9	14.5	2 117
Fruit and vegetable products	277	192.5	106.2	10.2	4 377
Fish processing	133	630.4	289.3	55.4	4 149
Bakery products	2 595	484.2	260.0	29.2	20 060
Cocoa products and sugar confectionery	232	71.4	33.1	3.9	1 742
Other sugar products	384	35.2	59.5	8.0	3 208
Cashew-nut processing	188	244.1	406.3	7.5	71 121
Manufacture of ice and cold storage	1 541	145.1	67.1	143.6	11 399
Manufacture of animal feed	125	106.0	69.4	3.9	1 153
Starch manufacture	119	50.8	46.7	5.3	2 153
Beverages	309	167.5	45.6	10.1	2 268
Other processed foods	922	269.1	153.7	28.3	12 819
Total	7 108	2 446.1	1 568.6	329.6	136 657
Percentage of total small-scale industries	(5.0)	(5.0)	(6.4)	(6.0)	(8.3)

Source: Census of Small-Scale Industries, 1977, vols I and II (Government of India, Development Commissioner, Small-Scale Industries).

TABLE 2. AGRO-BASED FOOD INDUSTRIES

Sector	*Number of units*	*Installed capacity (millions of t a)*	*Estimated production (millions of t a)*	*Estimated value of output (millions of rupees)*	*Estimated capital investment (millions of rupees)*
Rice mills	81 968	175.6			
Hullers	70 362	147.8	28–30	60 000	24 000
Modernized mills	11 606	27.8			
Dhal mills	–	30.0	6.1	20 400	8 160
Oil-seeds processing (power-driven)	15 000	13.5 (5.4)	2.6	15 600	6 240
Sugar	271	4.7	4.8	9 600	7 000
Gur and *Khandsari*		–	8.5	10 440	4 180
Cashew processing	240	0.40	0.072	1 350	540

TABLE 3. PROCESSED-FOOD INDUSTRIES

Sector	*Number of units*	*Installed capacity (thousands of t/a)*	*Estimated production (thousands of t/a)*	*Estimated value of output (millions of rupees)*	*Estimated capital investment (millions of rupees)*
Bakery products	48	187	150	535	213
Cocoa products and sugar confectionery	33	42.5	18.8	106	42.4
Dairy products	40	111	65	1 467	910
Roller flour mills	158	4 990	1 474.6	2 212.5	885
Fish products	300	575	60	1 250	500
Fruit and vegetable products	1 094	100	53	270	110
Starch and its derivatives	18	279.5	110	357	143
Soft drinks	34	1 731	730	212	85
Solvent extraction units	1 260	2 800	720	80	32
Cotton seed oil processing	86	1 300	73	314	126
Vanaspati	85	1 260	480	4 800	1 920
Miscellaneous foods	30	60	50	358.5	140

TABLE 4. PROCESSED-FOOD EXPORTS

	1965/66		*1975/76*	
Product	*Amount (t)*	*Value (lakhs of rupees)*	*Amount (t)*	*Value (lakhs of rupees)*
Canned and bottled fruits and vegetables, including dehydrated vegetables	2 367	43.4	8 775.7	481.0
Pickles, chutneys and condiments	2 438	44.7	5 373.0	277.8
Canned and frozen meat and poultry products	694	41.82	5 4[illegible]	499.0
Butter and ghee	7	0.7	63.6	11.0
Other milk products (including malted milk foods)	40	0.8	22.8	1.7
Canned and frozen fish and other sea foods	15 295	70.6	47 952.0	12 533.7
Biscuits	988	2.5	2 214.0	174.6
Confectionery	499	0.8	185.0	12.7
Papayas	531	1.1	983.2	5.2
Cashew kernels	51 266	274.0	43 206.0	8 019.9
Walnuts	4 885	18.4	4 003.1	323.9
Cocoa products	202	0.2	595.4	51.5
Guar gum and meal	–	15.7	26 890.8	1 135.0
Starch and its derivatives	–	–	2 978.4	43.3
Instant coffee	–	–	577.1	318.4
Spice oils and oleo-resins	–	–	65.1	61.6
Instant tea	–	–	483.1	193.6
Other processed foods	–	1.3	–	72.6
Coffee	26 371	1 294.0	58 919.2	6 412.0
Tea	14 738	11 483.7	212 296.0	83 681.0
Spices	60 525	2 559.0	31 182.3	7 096.0
Sugar, honey etc.	53 006	1 183.8	1 259 632.6	47 475.0

TABLE 5. INDIGENOUS PROCESSING TECHNOLOGIES IN INDIA

Industry	*Raw materials*	*Processing operations*	*Products*	*By-products*
Rice milling	Paddy	Shelling, polishing	Polished rice	Husk, bran
Maize milling	Maize	Debranning, degerming, grinding	Maize grits, maize *soojee*, maize flour	Husk, germ
Dhal milling	Pulses	Dehusking, splitting	Dhal	Husk, brokens
Oil milling	Oil-seeds	Expeller, solvent extraction	Oil	Husk, cake
Vanaspati	Refined oils	Hydrogenation	*Vanaspati*	–
Sugar and jaggery	Sugar-cane	Crushing, concentration, crystallization	Sugar, *gur*	Bagasse, molasses, sugar-cane wax
Flour milling	Wheat	Crushing, bran and germ separation, grinding	Flour	Bran
Dairy	Milk	Chilling, skimming, concentration, drying	Milk powder, skimmed milk powder, baby foods, condensed milk	Casein, butter, ghee
Bakery	Wheat flour	Baking	Bread, biscuits	
Confectionery	Sugar	Syrup boiling	Sweets	–
Meat	Animal meat	Freezing, canning, drying	Frozen, canned and dehydrated meat	
Fishery	Marine and fresh-water	Freezing, canning, drying	Frozen, canned and dried fish	Trash fish, fish bones, fish meal
Egg powder	Eggs	Drying	Egg powder	Shells
Fruits and vegetable processing	Fruits and vegetables	Canning, pulping, freezing, drying, miscellaneous processing	Canned products, pulps and juices, frozen and dehydrated products, pickles and chutneys	Peels, trims, stones
Alcoholic beverages	Fruit pulps, molasses, cereals	Fermentation, brewing	Wines, beers, hard liquors	Spent yeast
Coffee and tea	Coffee seeds, tea leaves	Special processes	Coffee powder, tea leaves and dust Instant coffee and tea	Spent coffee and tea
Spices	Spices	Drying, grinding, special processing	Dried whole spices, spice powders and oils and oleo-resins	Low-grade spices

Food storage and processing in Nigeria

*O. A. Koleoso** and *O. O. Onyekwere***

Introduction

The climatic conditions of Nigeria vary from south to north, as do the vegetation and crops grown. The coastal region is a mangrove swamp with an average annual rainfall of 430 cm between April and October. Humidity is about 95 per cent during the rainy season, and the average temperature is 30°C. The next zone beyond the coastal belt and extending well over latitude 8° North has moist tropical forests but slightly less rainfall. Tree crops are mainly palm and cocoa, and roots, tubers, maize and fruit are also grown.

The mangrove swamp zone sustains big forest trees. Swamp-rice production and fishing are the major occupations of the inhabitants of the zone. Relative humidity in the tropical forest area is as high as 90 per cent, with an annual rainfall of up to 130 cm and a temperature of 30°C.

The northern sector is savannah land, with a more open park-like grassland and hilly ranges. The northern extremities stretch out towards the Sahara Desert, but the northern frontier lies well within the limits of the summer rains. Rainfall in certain sections of the savannah zone is as low as 50 cm annually and the temperature can go up to 34°C, with relative humidity as low as 45 per cent between December and March. The principal crops here are millet, sorghum, ground-nuts, cowpeas, and sweet potato. Cattle, sheep and goats are reared. Chickens are exported to the south.

Tables 1, 2 and 3 in the annex to this paper contain information on foodstuff production and demand in Nigeria.

Although significant efforts are being made in Nigeria to produce food, traditional methods hamper output. Also counter-productive are tremendous food losses through improper storage and processing. Projections indicate that by 1985, the demand for cereals could increase by 90 per cent; for starchy foods, 35 per cent; for grain legumes, 50 per cent; for fruit and vegetables, 110 per cent; and 160 per cent for animal products.

Estimated losses in storage are as high as 20 per cent for maize in parts of southern Nigeria, 15 per cent for cassava and yams, 15 per cent for fruit and vegetables, at least 20 per cent for cowpeas and as little as 3 per cent for some oil-seeds. The combination of high ambient temperatures with humidity in most of the country is conducive to spoilage by micro-organisms and insect pests.

* [illegible] Director of Research, Federal Institute of Industrial Research, Lagos, Nigeria.
**Assistant Director, Federal Institute of Industrial Research, Lagos, Nigeria.

Food storage at different levels

Food storage in Nigeria is more or less by old-established and simple techniques.

Food crops are seasonal. A massive surplus during the peak harvest period is followed by a long period of relative scarcity and rising prices. As stockpiles cannot be maintained, the farmer quickly disposes of the bulk of the products, with poor financial returns. Ideally, a part of the products should be sold and the rest held in reserve for release into the market during the scarcity period. The best policy would be to finish selling preserved produce just before the next harvest.

Food production is very much underdeveloped. The farmer uses primitive farming methods, and sells part of the produce to pay taxes and to buy other necessities. The middle man buys up foodstuffs, and takes them to the urban areas for retail at considerable profit. Occasionally, co-operatives or the marketing boards purchase through agents and store the items in warehouses, ready for export. Food-processing industries buy up raw material requirements through agents or co-operative suppliers. There are, therefore, four categories of food storage to consider: the producer farmer (or co-operative), the trader, the food processor and the exporter.

For the purpose of this paper, food commodities are divided into the following categories:

(a) Vegetable sources, including fruits, leafy vegetables, cereals and pulses, roots and tubers;

(b) Non-vegetable sources, including meat, fish and milk.

Vegetables

The generally recognized techniques for food storage and processing are canning, drying and freezing. Sun-drying has been used to a large extent only by the farmers. At the village level, storage is almost non-existent. Fruit and vegetables are harvested while still slightly green and sold to the middle man. Much fruit quickly becomes overripe in the tropical rain forest zone. Damage during transport also induces microbial rot. The best thing to do is to cover the fruit with green banana leaves and leave it away from direct sunlight. Spoilage of fruits could reach 20 per cent in the peak season.

Vegetables, including okra, tomatoes, peppers and cultivated and uncultivated edible green leaves, flood the markets during the rainy season in the southern and middle belt zones but become scarce in the dry season (October to March). Onions are traditionally grown in the northern savannah area with their high temperatures and low relative humidity, presenting little or no storage problem. The other vegetables are dried in the sun or over the farmer's fireplace. Generally, however, freshly harvested vegetables are preferred, though a few urban households have deep-freezers and freeze their vegetables. Grapefruit is harvested almost green and wrapped in a specially treated waterproof envelope for export.

Perhaps the most developed established technology is the sun-drying of cereals and pulses. Methods for cereals vary from the humid parts of the south to the much drier north. Traditional storage of maize illustrates peculiarities in both areas. In the southern areas, which include the mangrove swamp and parts of the rain forest zone, maize is planted in April and is ready for harvesting in July, while the rains are still heavy. In the northern sector, the rains soon subside and maize is allowed to stand until the cobs dry. Maize in the south is too wet to store after harvest. The problem is to get the moisture down to 14 per cent, the recommended level for bag storage.

An ingenious method of drying is used in the south. The farmer stores the maize in a crib, which is a rectangular basket-like shed with legs made of bamboo. The bottom of the crib is made of palm leaves and the sides are of palm fronds woven into a basket. It has a thatched roof made of overlapping grass leaves. Maize cobs with the husks removed are carefully stacked and dried by air blowing through the corn layers. The maize nearest the outside dries first to about a 14 per cent moisture level and protects those in the centre from infestation and mould. The bamboo legs prevent the entry of rodents. The farmers build the crib in the village square, which is usually properly swept to prevent insect encroachment. Only chickens can pick at the maize, but the farmer, hoping to eat the chicken later, does not worry about this. This ingenious drying method costs the farmer next to nothing. When required for sale, the maize is removed, shelled and bagged.

The difference in northern Nigeria is that the maize is harvested when already pretty dry. Husked maize is stored in mud huts built up to prevent rodents entering and is shelled and bagged depending on market demand. Farmers working on a small-scale do not use insecticides, though in co-operative farms and Government-sponsored organizations, insecticides have been used on the cribs. In one instance, insecticide was applied to the floor of the mud hut prior to filling with maize. The drawback in this respect is that the maize cannot be consumed for at least three months, and that some insects become resistant to the insecticides.

Cowpeas harvested in November in the arid north are already quite dry and can be stored in the hut safely. However, when transported for marketing in the south, they become heavily infested with weevils. As much as 27 per cent damage with seven parasite holes per 100 beans in a Lagos market has been reported. The middle man trader takes no action to ensure that the items purchased and retailed are stored in good condition, because it is generally taken for granted that some foodstuffs, especially grains and legumes are bound to have insects anyway. There is no government regulation banning the sale of badly infested foodstuffs. The trader knows that even if the cowpeas are literally swarming with weevils, there are always poor people who will readily buy it, especially at a reduced price.

Ground-nuts, an important export prior to a drought disaster, is a crop of the dry grassland of the north, harvested in November when already quite dry. Crops are bought by agents of the marketing board which, for export, stock the bags in a square-based pyramid covered with tarpaulin in large open spaces. One pyramid can contain as much as 1,000 t. Each pyramid is fumigated by placing a plastic envelope containing fumigant over the top.

The storage of grains in silos is not recommended in Nigeria, unless linked to a food-processing factory. Silo engineering and machinery are highly specialized. The machines are not easy to repair and spares are not readily available. A southern co-operative farm had only an agricultural assistant to run its maize silo with no training in maintenance. When the conveyor system developed a fault, maize could not be removed and no one could repair the fault. Help was sought from a foreign country, but did not come until all the corn had gone mouldy, involving a huge financial loss.

Besides the lack of know-how, the economics of silo storage for grain are unfavourable, because the average moisture level has to be kept down to 12 per cent, an expensive process using the existing infrastructure. Worse still, grain is delivered in sacks, which have to be opened and emptied into the silo. When required for export, the grain has to be extracted, once more filled into the sacks, and sewn up. Labour is required for each operation and costs money and time. Large transnational food processors with silo facilities usually retain the services of highly paid silo engineers to monitor the temperature and humidity distribution in the silos and repair and service the machinery.

Cocoa is also an important foreign-exchange earner. The pods are harvested during the dry season in the south and the beans sun-dried on concrete slabs or on mats. They are bagged and stored in rodent-proof warehouses by the exporter, who has storage experts to ensure that the cocoa is in good condition. Slow-acting poison baits are used to check rodents which generally are not such a serious problem as insects. Whereas rodents only eat up the sacks and cause them to leak, insect pests can destroy a whole stock.

The storage of roots and tubers is as important for the country as grain. These are predominantly crops of the middle and southern areas. The yam barn is the principle way of storing yams used by the farmer. Here yams are tied on vertical poles under a little shade in the more humid areas, or merely heaped on the ground under a little shade in the drier areas. In both cases, losses of up to 15 per cent within three months are sustained through rotting, mould, or pithiness due to sprouting. Applying wet wood ash to damaged roots reduces fungal attack, and removing sprouts achieves partial control. However, only a small farmer can do this, though the method has been highly recommended even for co-operative farms. Storage of yams and sweet potatoes in an inert atmosphere (that is with oxygen almost removed) or by irradiation has been the subject of experiments and appears to have controlled sprouting for up to eight months. It is doubtful whether this could be of practical application in the foreseeable future.

Not much effort has been made to store cassava *(Manihot esculenta)*, and roots are pulled within 48 hours of use. Experimental storage for up to two months in boxes covered with wet sawdust overlaid with straw to maintain a high humidity and covered with sand has been reported. Low-temperature storage of yams and cassava is unlikely to be used in Nigeria.

Meat and fish

Fish is caught with nets and spoilage sets in rapidly. The fishing canoes have no facility for carrying insulated containers for the storage of ice and iced fish. In the northern sector of the country, especially in the Lake Chad area with high ambient temperature and low humidity, fish is usually sun-dried, being split and dipped in a pesticide solution beforehand, in the erroneous belief that this will prevent infestation. Occasionally the fish is gutted and bent into a horseshoe shape with the aid of a sharp stick piercing the tail and head. The fish is allowed to sun-dry to between 14 per cent and 30 per cent moisture without adding salt. Larger fish are cut into smaller pieces and smoked briefly over a charcoal fire, before being sun-dried.

Fish-smoking is the method chosen in the more humid parts of the south using mud kilns. In coastal areas where the art has attained some perfection, firing is aided by bellows. The greatest disadvantage of sun-drying is maggot infestation.

Large fishing and meat industries have refrigerated warehouses. Families without a refrigerator find it easier to deal with smoked and sun-dried fish, especially away from the coast. Imported and local chilled meat are now helping to improve nutritional levels. Milk, where available, is usually taken fresh or soon after boiling. The dairy industry is not yet developed.

Food processing

Traditional food processing, although having some merit, is generally unhygienic, time-consuming and uneconomic. A characteristic of indigenously processed foods is that most are fermented by natural micro-organisms without introducing pure strains, and have flavour profiles which, if altered, makes the food unacceptable. This does not mean that quality control measures are employed to obtain uniform products between one batch and another.

Cereals

Maize *(Zea mays)* is an important cereal of the south while sorghum is its counterpart in the north. Maize is traditionally eaten as a sour meal, referred to as *ogi* or *eko* in Nigeria, almost similar to the Ghanaian *kenkey*. It is made by soaking in lukewarm water for a day, wet milling in a hammer mill with the soaking water, sieving to remove coarse particles and allowing the filtrate to sediment. After decanting, the starch cake is made into a pap with boiling water. This food is generally used as a supplement to breast milk and as a breakfast cereal. However, it is nutritionally inferior to whole maize meal because of the loss of germ and other parts of the grain. The traditional method of preparation is generally unhygienic and in villages it does not keep for more than a day unless refrigerated. The fermentative organisms are yeasts and lactic organisms. Whole corn meal is prepared by pounding in a mortar followed by wrapping in leaves and steaming. The stiff dough is broken up, mixed with green vegetables and oil, and fried. Corn flour is processed by grinding and sieving. Sorghum is pounded in a wooden mortar, wrapped in leaves, cooked and eaten with meat and vegetable stew (like *fufu)*. Germinated sorghum can be prepared into malt from which a local beer known as *pito* is brewed.

The Federal Institute of Industrial Research (FIIR), Lagos, has improved the traditional fermented corn-starch food by incorporating soya bean flour, spray-drying and adding vitamins and minerals, to make a balanced infant weaning food known as *soy-ogi*.

Pulses

The cowpea (*Vigna sinensis*) is a good source of protein particularly for the inhabitants of southern Nigeria who do not have as much animal protein as their counterparts in cattle-rearing areas of the north. Cowpeas are washed and soaked in water for several minutes until the skin can be rubbed off and then milled on stone. The mash, mixed with onion and fresh pepper, is sometimes kneaded into a dough and then fried into fluffy and spongy cakes. Alternatively, the dough is wrapped in dried banana or other suitable leaves and cooked in water to a stiff meal to be eaten with palm-oil stew or with *ogi*.

Root crops

Yam (*Dioscorea* sp.) is an important food crop and farmers used to measure their wealth in terms of yam barns. To make a white stiff dough, yam is peeled, cut into pieces, cooked in water, and pounded in a wooden mortar with the addition of water, if necessary. For the preparation of yam flour (*elubo*), the root is peeled, sliced, left to sun-dry, and afterwards milled into a whitish powder. Put into boiling water, it goes black and is worked with a wooden pestle into a stiff gel. The dark colour is produced by non-enzymatic reaction, and has come to be accepted as normal. White flour has recently been produced experimentally by dipping sliced uncooked yam into a hot solution of a preservative (sodium metabisulphite), drying quickly in a hot-air oven at 200° C, milling and sieving. Traditional flour is sold in open basins and deteriorates rapidly in the humid tropical atmosphere. Some processors now buy sun-dried yams packed in polythene, which keep better.

Cassava (*Manihot esculenta*) is a root crop of great importance in southern Nigeria, where it is consumed principally as *gari*, a semi-granular, starchy product. By traditional methods of preparation, freshly uprooted cassava is peeled, grated on the reverse side of a perforated aluminium sheet and allowed to ferment naturally in jute bags with pressure applied for at least two days, during which time the moisture content is reduced by about half. The wet cake is then fried on a hot iron pot to a moisture content of nearly 20 per cent. The frying is unique in that optimum gelatinization of the starch is a major factor for acceptability.

Lower-income people who eat this food primarily for its filling value, desire that *gari* soaked in cold water should swell to at least three times its original volume. More than 40 million inhabitants of Nigeria use *gari* as a staple, which has a protein content of only 1.5 per cent and is low in minerals.

FIIR has successfully mechanized and commercialized an upgraded village technology. At present several plants are operating, two of them with a daily output of 10 t. This is a great improvement over the village scale where tedious, unhygienic methods, produce less than 200 kg per day. Industrially prepared *gari* has been known to keep for up to one year, compared to a village shelf life of less than six weeks.

Second in importance to *gari* is cassava *fufu*. For this, peeled roots are grated and allowed to ferment for one to two days in a closed vessel. To cook, a portion is added to boiling water and worked with a pestle to a stiff gel. It is eaten with a vegetable and meat stew containing palm oil. Starch is also processed from cassava and a recently established factory may produce enough to reduce imports of starch for textile processing.

Fruits and vegetables

The processing of fruits and vegetables by canning or freezing is still experimental. Apart from sun-drying of okra and some other leafy vegetables (for example *okazi*) little has been achieved compared with some other countries.

Meat products

Animals are slaughtered in abattoirs which are not generally of the highest hygienic standard. Meat is often sold in open market places, exposed to flies. Although most of the skins are processed into leather, the hooves and horns are generally discarded.

An interesting method of processing beef in northern parts is the production of *suya*. Slices are strung on a stick about 30 cm long, spiced with salt and ground, hot red pepper, and placed near a hot charcoal fire until done.

A form of cottage cheese known as *wara* is made from either cow's or goat's milk in parts of northern Nigeria, and despite a primitive method of production it is a favourite food with people used to it. Local butter, which can be likened to a European type of butter, is usually put into beer bottles without refrigeration. Cattle herdsmen prefer milk rather sour. It can be concluded that fermented foods are a distinguishing feature of Nigerian foods. As the organisms causing botulism in humans cannot survive in such acidic environments, most Nigerian fermented foods should, under better hygienic conditions, serve as excellent examples of food preservation in a developing country where micro-organisms flourish. However, because the fermentation is caused by wild strains of micro-organisms, it is impossible to have uniform quality.

It should be noted that no reference is made to food storage and processing in Nigeria by transnational corporations, the technology of which, for example in wheat milling, is too advanced for general use.

Although research institutions may adopt techniques such as hot air dehydration, controlled atmosphere storage, freeze-drying, irradiation, extrusion cooking and so forth, these technologies are manifestly inappropriate for the state of development of the country. Therefore, what is relevant is the upgrading of food technologies familiar to the people. This has been the approach by FIIR. Mention should therefore be made again of the Institute's success in mechanizing the traditional *gari*; protein enrichment of corn with soya beans based on the traditional fermentation process and upgrading of the sorghum alcoholic beverage *pito*. Another research institute has improved the grain-drying crib.

Attempts to mechanize food production are often hampered by lack of raw materials, with the result that some factories can only operate for a few months of the year. Therefore, increasing population and urbanization require not only increased agricultural productivity but also the saving of food by appropriate storage and processing techniques that will guarantee quantity, quality and nutritional value.

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Annex

FOODSTUFF PRODUCTION AND DEMAND IN NIGERIA

TABLE 1. MAJOR CLIMATIC ZONES OF NIGERIA AND RELATED CROP SPECIALIZATION

Ecological region	*Crops or livestock*
Mangrove swamp	Tree crops, fruits, vegetables, swamp rice, maize, grain legumes, fisheries, poultry
Moist tropical forest	Tree crops (palms), root crops and tubers, cereals, vegetables, legumes, fruits, poultry, pigs
Savannah	Cereals, legumes, livestock, some roots and tubers, seeds and nuts

Source: Based on data contained in S.O. Olayide and others, *A Quantitative Analysis of Food Requirements, Supplies and Demand in Nigeria, 1968–1985* (Lagos, Federal Department of Agriculture, 1972)

TABLE 2. PROJECTION OF DEMAND FOR FOODSTUFFS IN NIGERIA 1968–1985
(Tonnes)

Foodstuff	*1968*	*1975*	*1980*	*1985*
Cereals				
Maize, millet, sorghum, rice, wheat	6 115 402	7 653 995	8 919 962	11 616 362
Starchy roots				
Cassava, yams, potatoes, cocoyams, plantains	16 973 507	19 033 054	20 710 344	22 785 501
Legumes				
Ground-nuts, beans, soya beans, locust beans	779 172	909 812	1 023 403	1 178 967
Fruits				
Oranges, pineapples, papayas, bananas, mangoes	1 308 056	1 780 019	2 174 837	2 705 633
Vegetables				
Okra, fresh tomatoes, onions, pepper, cultivated and uncultivated edible green leaves				
Animal products				
Meat, fish, milk	2 138 818	3 287 586	4 249 5[illegible]5	5 596 786

Source: Based on data contained in B. N. Okigbo, "Problems and prospects of increasing food production in Nigeria", in *Proceedings of the 1st Symposium on Science and Technology in National Development* (Lagos, 1972), pp. 1–34.

TABLE 3. FOOD LOSSES DURING STORAGE IN NIGERIA, 1968–1969

Food commodities foodstuff	*Loss (percentage)*
Cereals	
Maize	10 (north)
	20 (south)
Millet	10
Sorghum	10
Rice	5
Wheat	2
Starchy roots and tubers	
Cassava	15
Sweet potatoes	15
Yams	15
Cocoyams	25
Plantains, bananas	5–10
Fruits and vegetables	15
Legumes	
Ground-nuts	10
Cowpeas	20
Bambarra ground-nuts	10
Soya beans	10–20
Oil-seeds and nuts	
Melon seeds (shelled seeds)	5
Sesame seeds	3
Cola nuts and coconuts	
Animal products	
Beef	[illegible]
Fish	25
Eggs	20

Source: Based on data contained in B.N. Okigbo "Problems and prospects of increasing food production in Nigeria", in *Proceedings of the 1st Symposium on Science and Technology in National Development* (Lagos, 1972), pp. 1–34.

Food storage and processing in Thailand

*A. Sawatdiat,** *M. Sundhagul*** and *P. Varangoon****

Major food processing industries in Thailand

The fishing industry is a major contributor to the economy of Thailand. Linkage industries such as cold storage, ice plants, refrigerated transport, canning, fish-meal plants, fish-sauce factories etc. have been established.

The bulk of the dairy industry consists of the manufacture of condensed and evaporated milk recombined from imported milk solids. Some fresh milk is locally produced for consumption, while some is locally processed into reconstituted milk. Production of fresh and pasteurized milk is growing at satisfactory rates. Sterilized milk has recently been introduced into local markets.

Canning is the major process for fruits and vegetables. Pineapples undoubtedly occupy the most prominent place; more than 90 per cent of them are exported. Other fruits include longans, rambutans, water chestnuts, lychees, fruit cocktails and mangoes.

Among the vegetables produced are bamboo shoots, asparagus, green beans, champignon and straw mushrooms, cream corns, and young sweet corns.

Traditional processed foods with good domestic markets are dried banana, pickled vegetables and fruits, fish sauce, shrimp paste, dried meat, pork sausage, fermented bean curd etc.

Fruit canning, dominated by the canning of pineapple for export, is the largest sector of the processed food industry. High demand from overseas has created rapid growth, and between 1973 and 1976 production increased almost fivefold.

In existence since 1967, the fruit-canning industry has a total capacity of approximately 120,000 t/a. The actual production is about 50 per cent of the capacity, and nearly 90 per cent of production is exported. Major problems are the supply of fruit of suitable quality and the instability of raw material prices. When possible, major canneries grow their own pineapples, using scientific methods of control. Attempts have been made to regulate production by using plant hormones, but the climate makes this difficult. Packers continue to have problems with seasonal supplies.

*Director, Product Development Division, Project Development Department.

**Director, Industrial Research Department.

***Director, Industrial Food Division, Industrial Research Department at the Applied Scientific Research Corporation of Thailand, Bangkok, Thailand.

To meet strict import restrictions of bodies such as the United States Food and Drug Administration, the Thailand Industrial Standards Institute (TISI) published specifications in 1973 on all details, ranging from sweetness to the number of pieces in the can. Canneries have to obtain export licences from the TISI, and the number issued has grown steadily.

Manpower requirements for the major canneries during the period 1973–1975 included approximately 6,000 workers in the peak season from April to August. Full-capacity production would require about 10,000 workers. In the early stages the canneries used relatively cheap equipment. Newer factories install more expensive high-quality equipment manufactured in Europe or the United States. A large cannery, the most modern in south-east Asia, opened in 1978, built at a cost of 170 million baht (B) ($8,500,000), with a production capacity of 2.4 million cases. Small operators utilize semi-automatic or manual methods.

World demand for canned pineapple stands at approximately 50 million cases per year. Thailand's main markets for pineapples are Canada, the Federal Republic of Germany, Spain and the United States of America. Competitors include Malaysia, Mexico, the Philippines and South Africa. Thailand is the world's third largest exporter and Asia's second largest supplier. It is felt that full capacity production might result in a world glut and perhaps a collapse of the local industry.

A preliminary study by the Applied Scientific Research Corporation of Thailand (ASRCT) and the National Economic and Social Development Board in 1976 showed the average production costs per case for the three major pineapple exporters. Their findings are reflected in the table.

PINEAPPLE PRODUCTION COSTS

Item	Average cost per case[a]	
	In dollars	Percentage of total
Pineapples	1.91	40.8
Cans	1.58	33.7
Syrup	0.18	3.9
Labour	0.19	4.0
Labels and paper boxes	0.44	9.4
Miscellaneous	0.38	8.2
Total	4.67	100

Source: K. Menasuit, "The canned foods industry", (Bangkok, The National Economic and Social Development Board, 1977).

[a]Size of case: 24 in. × 20 in. (61 cm × 51 cm).

The export distribution costs in 1975 were $0.475 per kg, or $7.40 per case.

The uncertainty of pineapple supply has led to price fluctuations and an increase from $0.056 to $0.076 per kg during the period 1968–1975. Competition from the local market for fresh fruit helps to ensure a continuing high price for the growers. Another benefit to them is that experts from the factories provide advice and training in the use of modern technology.

In 1975 Thailand exported canned pineapples at a value of B 345 million, and the value was B 600 million in 1976. In the first six months of 1978 the value was B 564 million. Thailand's infrastructure is an important factor helping to meet the requirements of investors in many provinces. There are attractive investment incentives, ample natural resources and a large labour pool, as well as a good network of national highways strong and wide enough to take any load, and farm-to-market roads. Distribution of electricity is improving rapidly.

The plantation area increases annually at the expense of sugar-cane and coconuts, reaching 6.4 million hectares in 1977. The socio-technological outlook of the farmers has at the same time undergone rapid change.

Area development factors

Of Thailand's total area of over 51 million hectares it is estimated that about one third is currently farmed or potentially arable. The population was estimated at about 43 million people in 1977, of which more than three quarters were engaged in agriculture.

Some of the provinces that produce canned fruit are as follows:[1]

(a) Lampang. Northern region, about 600 km north of Bangkok; total area, 12,518 km^2, of which 9,760 km^2 is forest, 1,200 km^2 paddy field, and 1,504 km^2 prairie; 1977 population, 643,260; income *per capita* per year, approximately B 5,471; the province has a rural structure, sugar-cane and canning industries, and is also a source of fruit and vegetables.

(b) Chon Buri. Eastern region, about 80 km from Bangkok; 632 km^2 under paddy field, 573 km^2 upland crops plantations and 1,020 km^2 forest; 1975 population, 644,052; income *per capita* per year, B 8,700.

The province is urban and rural, and has a sugar-cane factory, fruit and vegetable canneries, and many tapioca factories;

(c) Prachuap Khiri Khan. Central plain region about 400 km west of Bangkok; 1977 population, approximately 344,127; income *per capita* per year, B 7,000; the province is rural, has many pineapple canneries and forms the heart of the pineapple belt.

Future technological development

Pineapple canning is highly competitive, and is also labour- and capital-intensive. To make a profit, it is necessary to achieve economies of scale. Many factors can hamper the future prosperity of the industry, such as the insufficiency of suitable raw materials for canning, or labour unrest. International prices flutuate widely, influenced by exports from other countries.

A new dehydration technology is being applied to export fruits, starting with green cayenne pineapples, papayas and bananas. Dehydrated pineapples need only the addition of water, in accordance with instructions on the package, and can be chilled in a refrigerator. The customer then has slices of pineapple in syrup. The process can remove 80 per cent of the water content by using dry

[1]Information supplied by the Economic Studies Department, ASRCT.

steam. This leaves all the flavour and food value. Shelf-life is expected to be about six months, although in a cool dry place the period becomes considerably longer without losing flavour after reconstitution. Six tonnes of raw material peeled, cored, sliced, screened for defects and passed through the dehydrating oven are reduced to about one tonne. The weight of canned fruit is nearly three times the weight of dehydrated fruit.

With a capacity of 60 t per month, the investment for the plant is B 6 million, including machinery, equipment and imported technological expertise. It employs about 50 local workers. Many types of fruit such as seedless papayas have never been exportable fresh unless air-freighted at tremendous cost, and can be regarded as suitable for the process. Exports of canned fruit other than pineapple are small, but prospects are improving. Large companies are adapting their lines with the aim of diversifying to operate at full capacity the year round. They produce orange and tomato juice, asparagus, mushrooms and other fruits or vegetables available out of the pineapple season. Another pineapple product which seems to have a potential for export is quick-frozen flesh and concentrated juice. The technology has to be obtained from abroad. Investigation of the process aimed at conserving energy has been planned at ASRCT.

Utilization of waste

Pineapple waste consists of fruit residue from the canning process, and plant leaves and stems. Development of by-products from the leaves and stems has been slow. At present it is used for land filling and, to a small extent, cattle feeding. The emphasis in utilization is on the fruit residue, which might provide animal feed or the protein digestive enzyme, bomelin. Preliminary investigations in this field have been conducted at ASRCT, but support from foreign agencies is needed. Results could make a significant contribution to economic development.

Packaging problems

Except for companies with established foreign markets or linkages with foreign technology, packaging technology in Thailand is in an early stage of development. Domestic research lacks a laboratory with the necessary equipment. Problems in the packaging technology of Thailand as a whole are quality control, technical development and innovation. Because of this there have been examples of product loss or damage during distribution to export markets, and entire shipments have been rejected.

Research into the packaging of fruits and vegetables for export by air freight has been carried out with a view to developing standard containers and promoting standardization. ASRCT, the Industrial Research Service, Thai Airway International Limited, the Market Organization for Farmers, the Thai Packaging Association, the Export Service Center and Bangkok Airport Customs House conducted the project in order to make test shipments.

Another project for the application of flexible packaging materials to improve packaged products is being promoted by ASRCT. Research will be carried out on a product absorption isotherm, measurement of the moisture resistance of packages, and the shelf-life of packaged goods. Data concerning product sales, packaging, climate etc. could be used to estimate the type of moisture barrier films required to protect a moisture-sensitive product. ASRCT has the basic infrastructure and capability required to launch the project at this initial stage, but additional technical and financial assistance will be needed.

Status of food storage and processing technology in Thailand

*A. Bhumiratana**

Introduction

The countries of the Association of South East Asian Nations (ASEAN), except Singapore,[1] are considered to be developing countries with economies dependent largely on agricultural products. Table 1 shows that in 1975 their agro-based exports, especially natural rubber, palm-oil, coconut products and spices had dominant shares in the world market.

TABLE 1. AGRO-BASED COMMODITY EXPORTS OF ASEAN COUNTRIES IN 1975

Commodity	*Value (dollars)*	*Percentage of world exports*
Natural rubber		
Indonesia	361 996	
Malaysia	782 254	
Thailand	175 000	
	1 319 250	82.92
Palm-oil		
Indonesia	151 639	
Malaysia	594 524	
Singapore	73 362	
	819 525	83.57
Coconut, copra and coconut oil		
Malaysia	27 511	
Philippines	402 666	
Singapore	16 708	
	446 885	63.62
Spices (pepper)		
Indonesia	22 867	
Malaysia	43 662	
Singapore	45 769	
	112 298	57.16

*Director, Institute of Food Research and Product Development, Kasetsart University, Bangkok, Thailand.

[1]The members of ASEAN are Indonesia, Malaysia, Philippines, Singapore and Thailand.

TABLE 1. AGRO-BASED COMMODITY EXPORTS OF ASEAN COUNTRIES IN 1975 *(continued)*

Commodity	*Value (dollars)*	*Percentage of world exports*
Rice		
Thailand	293 000	9.21
Sugar		
Philippines	580 736	
Thailand	281 122	
	861 858	7.26
Forest products		
Indonesia	679 064	
Malaysia	662 952	
Philippines	246 775	
	1 588 791	15.09

Sources: Food and Agriculture Organization (FAO), *Trade Yearbook*, 1975, vol. 29, and FAO, *Yearbook of Forest Products, 1963-1974*; *Yearbook of International Trade Statistics, 1975* (United Nations publication, Sales No. E.76.XVII.10, vols. I and II).

In order to maintain quality, minimize losses and fully utilize the agricultural products, it is necessary to improve techniques and management in food handling, food processing technology and utilization of waste materials.

PRESENT TECHNOLOGY

Food storage

Post-harvest and storage losses of all types of food may be reduced by physical control and by chemical control.

Physical control. Reduced temperatures and refrigeration are probably the best means of reducing losses of perishable products. Refrigerated storage is common for fish and meat, but since the cost is extremely high and results may in certain cases be adverse, less expensive systems of slightly reduced storage temperatures, perhaps in combination with other measures, may be adopted. Reduced temperature storage is effective because it slows down metabolic processes and cuts losses caused by such factors as sprouting and rotting. Heat or high-temperature treatment has been effectively used as a treatment prior to storing some products.

Chemical control. Chemicals and pesticides can be used to reduce disease losses, but a thorough knowledge of the diseases involved is required. Due to residual effects, most chemicals have to be used under strict control and by trained personnel.

Nearly 50 commercial cold-storage facilities, able to accommodate from 25 to 10,000 t of food, exist in Thailand. Nine others, with space for 16,000 to 280,000 t have drying and silo facilities.

Food processing

Food is produced both to meet local demand and for export. Meeting local needs presents problems of quantity, quality and nutrition. Lack of knowledge about nutrition, linked with traditional eating habits, hampers the introduction and distribution of new forms of nutritious food. Furthermore, low incomes of many families make price a serious consideration. Locally available raw materials will of course be essential components in such new products.

Important factors affecting food for export are quality and price. Accordingly, production has to be well planned and highly competitive.

Thailand's Industrial Development Plan is focused on labour-intensive industries, high value added, high utilization of local raw materials, and export orientation. One of the objectives is to promote the food industry and, as a corollary, agro-industries.

The First and Second Development Plans were aimed at establishing state enterprises and promoting investment through revised legislation. Industrialization expanded from 1961 to 1966, and the share of manufacturing in the gross domestic product (GDP) rose from 13.1 per cent to 13.7 per cent, that of food manufacturing being 4.9 per cent in 1961 and 3.9 per cent in 1966. The number of factories registered under the Factories Act increased from 2,400 in 1969 to 4,634 in 1975. However, in the Third Plan (1972–1976), foreign investments dropped due to the oil crisis in 1973 and political uncertainties in 1974–1975.

Compared to a 6.9 per cent compound annual growth rate of all manufacturing between 1971 and 1974, food, beverages and tobacco was 3.1 per cent. This compared well with an expansion of 0.5 per cent annually for the whole economy. Unfortunately, the share of food manufacturing in GDP declined between 1960 and 1974, because other industries were more attractive under the Investment Act, and there was also a lack of government agencies collecting or surveying information on cottage-type and small-scale food manufacture. Grain milling and beverages were the two food industries contributing most in gross value added in 1963 and 1973 while the gross value added of sugar factories and refineries dropped. Total employment in manufacturing was 711,000 in 1969 and 1,693,000 in 1974, of which 63,000 (8.9 per cent) and 107,000 (6.4 per cent) respectively were engaged in food processing. Because these industries grew more slowly than others, the Government is preparing a special programme for agro-industries.

Among food products (major groups 311, 312 and 313 of the International Standard Industrial Classification), grain, tapioca, sugar, and molasses, bean curd and pineapple, are important for exports. In terms of domestic consumption, the most important products are grain, sugar, vegetable oil, dairy products, animal feeds, meat, soft drinks and beer. Table 2 reflects the relative importance of some of the 27 food-processing industries.

TABLE 2. SELECTED FOOD-PROCESSING INDUSTRIES IN THAILAND AND BANGKOK

Industry	*1969*		*[illegible]*	
	Thailand	*Bangkok*	*Thailand*	*Bangkok*
Preserved, dehydrated, quick-frozen fruits and vegetables	6	4	33	21
Animal and vegetable oils and fats	5	2	105	22
Husking, cleaning, polishing rice	505	6	25 868	131
Flour	8	3	306	125
Blended grain seeds and roots	7	3	81	37
Tapioca	3	1	849	4
Bread, cakes, biscuits etc.	5	5	126	70
Food from starch	3	2	155	25
Coffee roasting	3	3	79	58
Flavouring	7	5	87	23
Animal and fowl feedstuffs	8	2	134	17

Most products need no processing and minimal storage technology, e.g. rice, seeds, oil-seeds; need only one or two processing steps, e.g. tapioca chip and corn; or are fully processed, such as tapioca starch and milled rice, and canned, dried or frozen foods.

In most developing countries, especially in Asia, exported products are mainly in the form of raw materials. Close to 140 types are exported from Thailand, where the total value originating from agricultural forestry and fishery sources represented 75.9 per cent of all exports from 1970 to 1976.

Prior to developing its own food-processing industries, Thailand relied mainly on imports to meet the domestic demand for processed foods. In 1965 milk and milk products such as condensed, dried or evaporated milk, were major imports, as were coffee, tea and beverages. There was, however, a marked decline in the import of milk and milk products after domestic milk industries were established.

The biggest processed food export is sugar, which in 1976 reached its peak and figured prominently among total exports. Tapioca pellets are a close second. One outstanding recent export has been shrimp.

Exports of canned pineapple increased dramatically after 1971, the main markets being the Federal Republic of Germany, Japan, the Netherlands and the United States of America, due to high quality, competitive prices, and decreased production elsewhere.

Sun drying, which is the oldest method and involves both low cost and limited energy consumption, is still used to preserve food, although only in the last decade has a serious study of the process been made. The advantages of dried food, whatever the method, are as follows:

(*a*) Increased chemical stability, e.g. against enzymatic deterioration;

(*b*) Stability against microbial spoilage;

(*c*) Reduction of weight and volume;

(*d*) Lower transport costs;

(*e*) Cheap storage at ambient temperature.

Some foods effectively sun-dried are cereals, fish, crustaceans, fruits and vegetables.

An essential factor lacking in developing countries is the technology to transform raw material into products to be marketed at a much higher price. Another major obstacle is the lack of funds for investment. The Government of Thailand's efforts to stimulate investment include provisions for low interest, long-term loans and tax exemptions. Improved acceptability of goods has been achieved by enforcing food standards.

Conclusions

To sum up, advanced technology for food storage and processing is still needed for the country to improve its economic status. In processing food for local consumers, simple technologies such as solar heat for drying, traditional fermentation and the osmosis process in salting and sugaring should be used and improved. Sanitation and safety are extremely important, especially if the technologies are to be applied at the cottage level and in home industry. Techniques of drying, of the use of colouring agents or other additives, and a knowledge of contaminations should be developed. One method of teaching and transfering technologies is the use of mobile units for rural areas.

For the export market, canned food has an important role. Since the export market is usually highly competitive, specific government organizations will have to take care of the quality and quantity of products. The Government should promote the export of processed or semi-processed products instead of relying heavily on raw agricultural goods.

ASEAN PROTEIN PROJECT

Since 1974 a major programme of co-operation among the ASEAN countries has been attempting to solve malnutrition problems, especially in the rural areas. Called the ASEAN Protein Project, it is searching for and developing high-protein low-cost foods for vulnerable groups of people. Support has been given by the Australia-ASEAN Economic Co-operation Programme, a project which has brought great co-operation between scientists and technologists. High-protein low-cost foods being developed include baby food, biscuits, condensed and dehydrated soy milk, textured vegetable proteins, leaf protein isolates and many others, and some of those developed in one country are being tried for acceptability in others. To help identify the best methods of introducing new foods, an extensive survey has been conducted in all five ASEAN countries to study eating habits. Production of full fat soy flour (FFSF) and its utilization in various high protein foods have also been the subject of intensive study. A factory to produce 100 tonnes of the flour a month has recently been completed. New and improved fermentation technology is also being tested.

The ASEAN Protein Project has strengthened co-operation among institutes, universities and government offices in the region and helped to improve the infrastructure of each country.

THE UTILIZATION AND MANAGEMENT OF WASTE MATERIAL

Surveys in Thailand and other ASEAN countries indicate that a tremendous amount of useful material is thrown away. Adoption of appropriate technologies could have the dual effect of decreasing pollution and at the same time making good use of the pollutants. An extensive study has identified large quantities of some food waste which could yield by-products useful for human food, animal food or energy. For food processing in particular, at least three promising processes offer, it is reported, potential for the effective management and utilization of waste. Those processes are as follows:

(a) Fementation to biogas (methane), now widely applied for animal waste, may be adapted to the treatment of large quantities of waste arising from pineapple canneries, tapioca starch factories and banana packing and processing plants etc. Other fermentation techniques can improve the quality of waste for use as animal feed;

(b) Reverse osmosis and ultrafiltration separate substances by passing them through special membranes. New membranes, more efficient, durable and economical than before, may assist techniques for recovering protein from starch factories and clean water from effluents, and in concentrating coconut water for canning or bottling;

(c) Food wastes unsuitable for human consumption may be fed to fish, ducks, chickens, pigs or cattle, and possibly pelletized for transportation.

Many other possibilities exist. The harvesting of rice generates rice straw at the rate of approximately 4 t/ha. During milling, 20-25 per cent rice husk and 6 per cent rice bran are left. At present, rice straw is being used as cattle feed, for paper-making, for cultivation of mushrooms, and as a soil-conditioner. Rice husk is used as fuel, as bedding for poultry and livestock, for packing, as building material, as a soil-conditioner and in making activated carbon. Rice bran is used for animal feed and for extracting oil. Some new approaches to the utilization of rice straw as animal feed could be devised; rice husk can be used for making carbon black, and may help to provide furfural, an important raw material for the chemical industry. Effluents from tapioca starch manufacture have a high content of suspended organic matter and dissolved solids, and might be subjected to reverse osmosis or ultrafiltration. Pineapple canning generates large quantities of effluent of high biological oxygen demand (BOD) content, and also solid waste. Proposals are that the solid waste may be pressed and dried for cattle feed, perhaps after microbial fermentation, or used as a source for biogas (methane).

PLAN OF ACTION

After establishing the status of the food industry and technologies needed for food storage and processing, a specific plan should be drawn up to establish guidelines and measures to be adopted. Recommendations for developing countries are as follows:

(a) Evaluations should first be made of agricultural products to ensure that enough is available for the people in the country, and then of methods of distribution. Development or transfer of technology in handling and processing may facilitate distribution;

(b) Raw materials for the food industry are usually initially derived from those which saturate the fresh foods market. A master plan interlinking agricultural and industrial developments should be mapped out by the Government. Where a processing industry is created to compensate for over-supply to the fresh foods market, the products will probably be used for local consumption. It will be extremely difficult to develop export markets since the industry must not only satisfy strict standards, but also be in constant supply;

(c) At the cottage level, special attention must be paid to hygienic quality. Health hazards may result from micro-organisms, toxic materials, contaminated materials or faulty containers. Food-processing methods which should be promoted here are dehydration and osmosis. Food canning is unlikely to be successful. The Government should create an office to advise on home-processed foods and to point out their dangers;

(d) National food laws should emphasize promotion of a food industry, consumer safety and export orientation;

(e) Special attention has to be paid to standards. Establishing a common standard for a specific food product for all regions and countries in the world is a very difficult task. The Food and Agriculture Organization of the United Nations (FAO) and the World Health Organization (WHO) have been involved in preparing an alimentary codex for twelve years, but a complete standard for a single product has yet to be fully accepted by all countries. Manufacturers thus have to be aware of requirements of buyer countries concerning contaminants, additives, pesticide residues, labelling, gross and net weights, quality, processing, packaging and handling;

(f) It is essential that marketing information be made available, to keep manufacturers aware of questions of supply and demand.

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Annex I

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Canned coconut milk *(gata)*, p. 104.
Pectin, oil and calcium citrate from limes, p. 106.
Production of weaning food, p. 107.
High fructose corn syrup production, p. 106.
Improved method for manioc processing, pp. 109–110.
Solar grape drier, pp. 111–112. diagram.
Processing of cashew nuts, p. 113.

Hand texturizer for food processing. pp. 114–116. diagram.

Gari-processing machinery. p. 117.

Vinegar from coconut water. pp. 118–120. diagram.

Chamber for smoking fish. pp. 121–122. diagram.

Mini thresher. p. 126.

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M. El-Mallah

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D. Adair

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Annex II

WORKING GROUP PARTICIPANTS AND OBSERVERS

Participants

L. A. C. Alles, Chief Research Officer, Fruit and Vegetable Utilization Laboratory, Department for the Development of Marketing, Colombo, Sri Lanka.
M. Bellini, Technica Moderna s.p.a., Turin, Italy.
A. Bhumiratana, Director, Institute of Food Research and Product Development, Kasetsart University, Bangkok, Thailand.
J. E. Cecil, Section Head, Industrial Development Department, Tropical Products Institute, London, United Kingdom.
K. K. S. Chauhan, Commercial Manager, Food Corporation of India, New Delhi, India.
G. M. Jhala, Managing Director, Indian Dairy Corporation, Baroda, India.
J. Keddie, Scottish Development Agency, Glasgow, Scotland, United Kingdom (Rapporteur of the Working Group)
B. B. Kshetry, Deputy General Manager, Nepal Food Corporation, Kathmandu, Nepal.
K. P. Kymal, Executive Director, Food and Nutrition Board, Ministry of Agriculture, New Delhi, India.
R. P. Morgan, Director, Center for Development Technology, Washington University, St. Louis, United States of America.
S. Mulitsch di Palmenberg, President, Italian Packaging Institute, Milan, Italy.
C. P. Natarajan, Director, Central, Food Technological Research Institute, Mysore, India.
O. O. Onyekwere, Consultant, Federal Institute of Industrial Research, Lagos, Nigeria.
X. Perez-Villasenir, Professor, Department for Biotechnology, Universidad Autonoma Metropolitana, Mexico D. F., Mexico.
D. H. Shin, Chief, Agricultural Service Section, Agriculture and Fishery Development Corporation, Food Research Institute, Seoul, Republic of Korea.
M. Sundhagul, Director, Industrial Research Department, Applied Scientific Research Corporation of Thailand, Bangkok, Thailand.
M. Thant Tyn, Head, Research and Development Division, Food Stuff Industries Corporation, Rangoon, Burma. (Chairman of the Working Group)
P. Varangoon, Director, Industrial Food Division, Applied Scientific Research Corporation of Thailand, Bangkok, Thailand.
B. K. Varma, Director, Indian Grain Storage Institute, Ministry of Agriculture and Irrigation, Hapur, India.

Observers

B. H. Mustapha, Principal Assistant Secretary, Ministry of Agriculture, Kuala Lumpur, Malaysia.
H. G. R. Reddy, Senior Industrial Development Field Adviser, ESCAP/UNIDO Joint Industry Division, Bangkok, Thailand.
S. N. Sharma, Deputy Manager, Planning and Research, Food Corporation of India, New Delhi, India.

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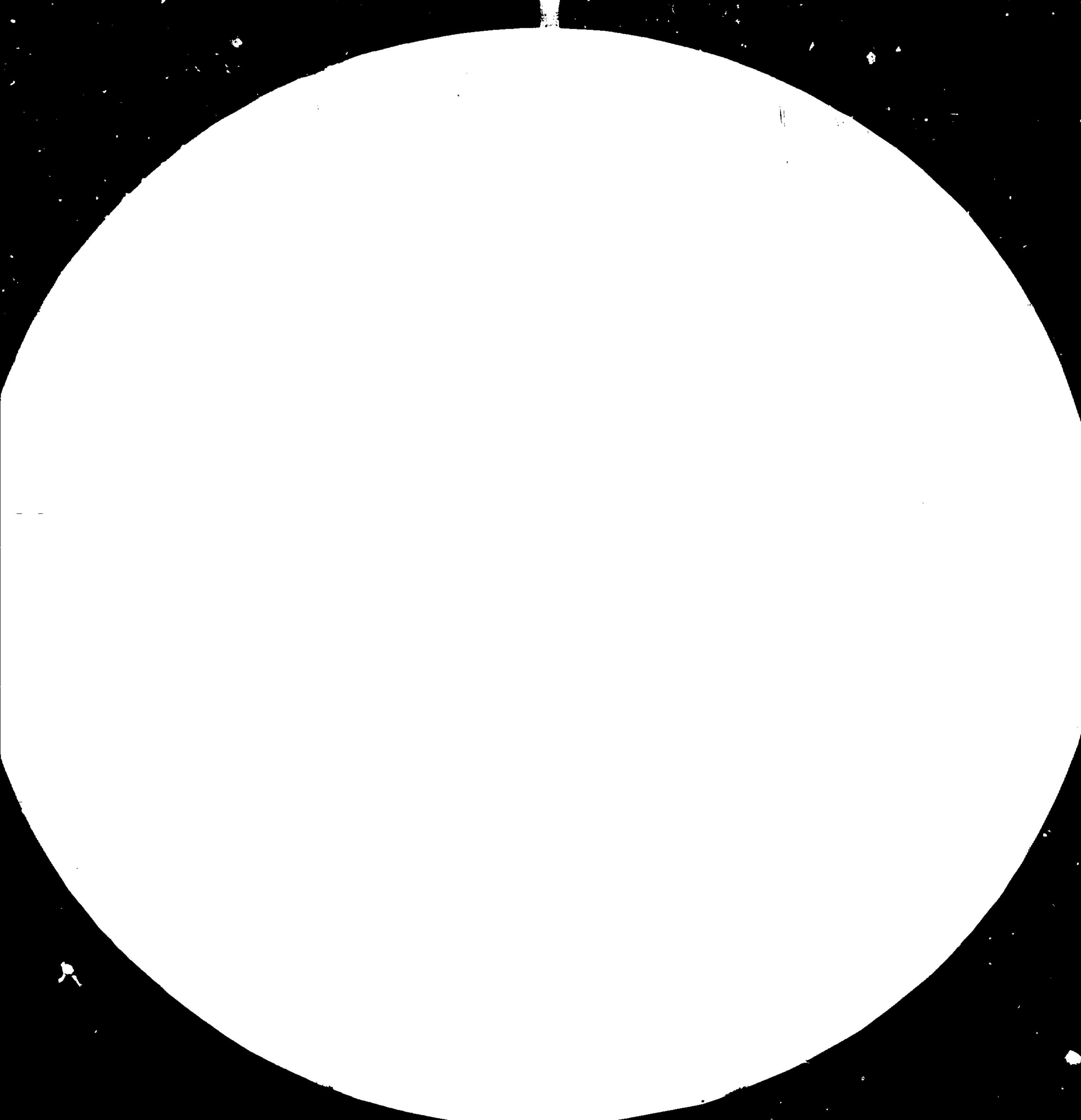

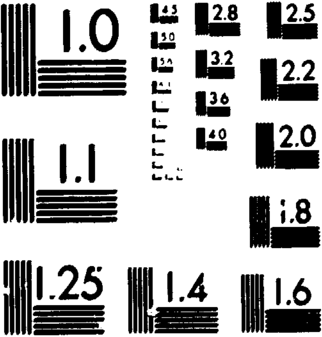

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Corrigendum

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The last entry *should read*

H. G. R. Reddy, Senior Industrial Development Officer, ESCAP/UNIDO Division of Industry, Housing and Technology, Economic and Social Commission for Asia and the Pacific, Bangkok, Thailand.

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