OCCASION

This publication has been made available to the public on the occasion of the 50th anniversary of the United Nations Industrial Development Organisation.

DISCLAIMER

FAIR USE POLICY

CONTACT

Please contact publications@unido.org for further information concerning UNIDO publications.

For more information about UNIDO, please visit us at www.unido.org

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

Distr.
LIMITED

UNIDO/IS.630
20 May 1986

ENGLISH

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

15570

CAPITAL GOODS IN OILSEEDS PROCESSING AND GRAIN MILLING INDUSTRIES

Sectoral Working Paper Series

No. 48

I. Ben-Gera

Sectoral Studies
Studies and Research

V.86-56570

SECTORAL WORKING PAPERS

In the course of the work on major sectoral studies carried out by the UNIDO Division for Industrial Studies, several working papers are produced by the secretariat and by outside experts. Selected papers that are believed to be of interest to a wider audience are presented in the Sectoral Working Papers series. These papers are more exploratory and tentative than the sectoral studies. They are therefore subject to revision and modification before being incorporated into the sectoral studies.

This paper was prepared by Dr. Itamar Ben-Gera as UNIDO consultant. The views expressed do not necessarily reflect the views of the UNIDO secretariat.

Preface

The purpose of this study is to provide the basis for an examination of the capital goods requirements in the food processing industry, especially in the oilseeds processing and grain milling industries.

As a part of the general objective of identifying the capital goods requirements, an immediate objective of this study is to identify the peripheral capital goods that the grain milling and the oilseeds processing line have in common. This study is, therefore, an attempt to show manufacturers of capital goods in developing countries how their production possibilities can be expanded to new lines of production in order to satisfy the demand of other industrial sectors, such as the two subsectors which are emphasized here.

This study has been undertaken by Sectoral Studies, UNIDO, in collaboration with Dr. I. Ben-Gera, as a UNIDO consultant.

Contents

Page

Figures

EXPLANATORY NOTES

References to dollars ($) are to United States dollars, unless otherwise stated.

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

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

A slash between dates (e.g., 1980/81) indicates a crop year, financial year or academic year.

Use of a hyphen between dates (e.g., 1960-1965) indicates the full period involved, including the beginning and end years.

Metric tons have been used throughout.

The following forms have been used in 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 up precisely because of rounding.

1. INTRODUCTION

This report deals with capital goods for the food processing industry and particularly with those required for the grain milling subsector and the oilseeds processing subsector. The report analyzes these two subsectors according to their unit operations and the core and peripheral capital goods which they utilize. This study is, therefore, an attempt to show manufacturers of capital goods in developing countries how their production possibilities can be expanded to new lines of products, in order to satisfy the demand of other industrial sectors, in this case the grain milling and oilseeds processing branches.

As part of the general objective of identifying the capital goods requirements in the food processing industry in developing countries and those that have a potential for local production, an immediate objective of this study is to identify the peripheral capital goods that the grain milling and the oilseeds processing lines have in common. The possibilities of developing countries to produce certain core capital goods are limited, since the technology equipment package belongs to a rather small number of transnational corporations.

In the preparation of this study advantage was taken of already available analyses of agrofood capital goods prepared by UNIDO as well as other UNIDO publications. Furthermore, use was made of technical publications and technical literature as well as publications, brochures and bulletins of manufacturers of capital goods for the food industry in general and for the grain milling and oilseeds processing in particular.

Chapter 2 gives a review of the main production processes for vegetable oils and fats and for grain milling. The review deals with the milling industries of the leading cereals world wide - wheat, maize and rice - and with the technologies that are utilized in these industries. It also reviews the technology in the field of oil extraction and processing. Cereals differ in morphology composition, structure and grain characteristics. This results in the need for different milling technologies, milling techniques and equipment. A variety of oilseeds are utilized world wide for vegetable oil extraction. These include, among others, soybeans, cottonseeds, peanuts, rapeseed, safflower, sunflower and sesame.

Chapter 2 gives also a breakdown of the most important capital goods utilized in the grain milling industry and in the vegetable oil industry in terms of core and peripheral capital goods and gives the classification into these two groups for both sub-sectors based on the complexity index criteria.

Chapter 3 reviews the basic problems and issues affecting the development of the manufacturing industry of capital goods for food processing in general and for oilseeds processing and grain milling in particular.

Following a short review of the benefits to the national economy attainable through the development of a capital goods manufacturing industry, a number of key issues are discussed. The first issue is that of demand and of competition. Demand depends on different factors. It is related to the price and availability of the product and to the level in which it is required, but also to the purchasing power of the consumer. The demand for vegetable oil and the demand for ground grain will influence the size of these industries on a national and regional level and could help in establishing the demand for processing equipment. Study and knowledge of these dynamics could help in estimating the demand for core or peripheral capital goods that will be generated through the demand for more vegetable oil or more milled grains. Availability of capital for investment, both in vegetable oil producing and grain milling plants, as well as in the capital goods manufacturing industry, will determine the level of the development of the capital goods manufacturing industry. The capital goods industry requires construction of new factories or enlargement of existing ones. It is noted that both grain milling and oilseeds processing installations located in different developing countries are utilized to date below capacity. This should to some extent dampen the demand for additional capital goods.

The way in which leading manufacturers of capital goods for the food industry in general, and that of the relatively few companies which dominate the equipment sector for grain milling or oilseeds processing is also presented.

Chapter 3 also discusses the issues of know-how, engineering and services. These are issues of paramount importance for the success of a capital goods manufacturing industry. It emphasizes the importance of engineering skills on a national and local level, and the role that they can play in helping to minimize importation of capital goods to the level required, and assisting in the development of a local capital goods manufacturing industry. The importance of training of technicians at all levels is discussed as well.

Chapter 4 is devoted to the main findings and recommendations. Several recommendations are made. Basically, these recommendations are related to the determination of the possible future or actual demand for capital goods for the food industry subsectors studied here, and possibly others, to study and determine what should be done in order to bring about an improvement in local capabilities in developing countries to manufacture capital goods, and finally to initiate a programme that will guide the local government. This guidance may be required in formulating policies that will result in increased involvement and activities in the local capital goods manufacturing sector by foreign and local companies. The final recommendation deals with the need to study and analyze training requirements and assist national governments in planning and execution of training programmes.

2. CAPITAL GOODS IN THE OILSEEDS PROCESSING AND GRAIN MILLING INDUSTRIES

2.1 General

This chapter reviews the basic processes employed in the production of vegetable oils and fats and in grain milling at different levels of sophistication. It covers the production of oils and fats from copra, palm, soy, cottonseed, rapeseed, sunflower, safflower, peanuts and the milling of wheat, maize and rice.

2.2 Processing of seeds, vegetable oils and fats

2.2.1 General

The vegetable fats and oils industry is very old. Different technologies are employed by this industry to accommodate a large variety of raw materials, processed under different local conditions. This industry has moved from old techniques to modern technologies. Mechanical screw pressing and solvent extraction dominate world wide. A number of equipment manufacturers with vast experiences and know-how offer both turn key projects and supply of individual pieces of equipment to potential and existing oil producers.

2.2.2 Preliminary preparatory steps: unloading, cleaning, drying and storage of vegetable oil bearing materials

Vegetable oil bearing raw materials (oilseeds) can be delivered to the processing plants in bulk ships, bulk railroad cars, bulk trucks, boxes, field boxes, sacks or bags. Unloading installations are designed to accommodate methods of oilseeds delivery. Plant size and selection of technology depends on local economic conditions and on the raw materials availability. This will be emphasized in a different part of this study.[1/]

1/ See Gustafson, E.H., Loading, unloading, storage, drying, and cleaning of vegetable oil-bearing materials, in: Journal of the American Oil Chemists' Society, June 1976, pp. 248-250.

(a) Unloading

Bulk trucks are usually emptied by elevating the front end of the truck on a platform and letting the raw material slide out and into the receiving pit. Conventional conveying systems such as chain, drag, crew or belt conveyors and bucket elevators can be used for most oilseeds. Some like copra and palm fruit require special considerations in design or in care of handling. Pneumatic unloading systems and marine legs are efficient unloading systems. They can reach a throughput of up to 2,000 tons of oilseeds per hour. Pneumatic unloading systems of a much smaller capacity can be utilized as well. Requirements depend on the size of the oilseeds processing facility and the organization of the raw material flow. Unloading can be done sometimes with the help of forklift trucks (olives) or manually, when oilseeds are delivered in sacks or in bags.[2/]

(b) Cleaning

Cleaning of oilseeds removes sand, dirt, stems, leaves, weed seeds, stones, metals, field wastes etc. This operation involves a series of shaking or vibrating screens. Removal of dust as well as light weight materials can be done by aspirators. This step in the process yields separately clean oilseeds, stones, metal pieces, sand, dirt etc., and dust free air.[3/]

(c) Drying

In order to ensure oilseeds quality and safe storage, moisture in incoming oilseeds needs to be monitored and in most cases reduced to a level (which is different for to each oilseed variety) which will assure safe storage. This is achieved in the receiver dryer. Free flowing type oilseeds are dried in conventional grain dryers. Drying is done by subjecting the

---

2/ Ibid.

3/ Galloway, J.P., Cleaning, Cracking, Dehulling, Decorticuting and Flaking of Oil-bearing Materials, in: Journal of American Chemists' Society, pp. 271-274.

oilseeds to heated air with the subsequent loss of oilseed moisture to the drying air. Once drying is completed, and prior to the storage of the oilseeds, ambient air is used for cooling. Grain drying and cooling requires heating of drying air by steam, gas or oil, and the flow of heated air through the moving bed of the oilseeds. Recirculation or partial recirculation of the hot and humid air prior to release to the atmosphere will save drying energy. Re-use of air for heating and drying of ambient air after its use as cooling air, will also save energy as the air after its use as cooling air will have a higher temperature than ambient air.[4/] Sun drying as well as belt dryers over open fire of non free flow oilseeds like copra, is practiced as well.

(d) Storage

Removal of excess oisture through drying and removal of mineral and vegetable waste through cleaning are necessary for safe storage. Soybeans, flax seed, safflower, shelled peanuts, sunflower, castor beans, rapeseeds, seasome seed, delinted cottonseed can be sorted in grain type storage facilities. These storage facilities could be steel tanks or concrete structures. Storage conditions differ and depend on the type of raw material, moisture content, degree of maturity, raw material temperature at the time of entry to the store as well as other factors.[5/]

2.2.3 Preparatory steps: tempering, cooking, cracking, dehulling, shelling, conditioning and flaking

The conventional system for soybean preparation following storage consists of tempering bins, a further cleaning with aspiration, scales, cracking mills and a dehulling system. The cracked beans are aspirated in multi-aspirators to remove the hulls. This is done more than once in order to

---

4/ Gustafson, E.H., op. cit.

5/ Ibid.

remove the maximum amount of hulls from meats. Peanuts have to be shelled and separation of shells and kernels is achieved by aspiration. After delivery to the plant and following weighing palm fruit in clusters is cooked in sterilizers.6/

(a) Tempering and conditioning

The tempering and conditioning methodology varies according to the oilseed and depends also on the method of oil extraction. A conditioner is used in the oil mills before crushing or flaking, so that moisture can be added and proper flaking can be achieved. Conditioners can be of the vertical or horizontal rotary type. These are usually circular structures, jacketed, heated with steam and fitted with steam injection and water injection ports. Soybeans are usually tempered before dehulling and are conditioned again after dehulling and prior to flaking. Another method of conditioning is by employing a fluidized bed system. While the conventional process involves oilseeds drying, cooling and storage in tempering tanks prior to cracking, this new process is a continuous one and the oilseeds are only heated once. They are cracked warm and the hulls are separated. The product is simultaneously conditioned and the cooling and tempering steps are eliminated.7/ Palm kernels are cooked in sterilizers at 140° for 60-90 minutes. This stops the development of oil acidity and allows separation of the fruit from the stem. It also eases the separation of the kernels from the fruits. The sterilizers are cylindrical and horizontal and are equipped with quickly closing doors. Palm fruit is loaded into the sterilizers in carts moving on rail tracks. Once all the air is purged, steam fills the sterilizers until the desired temperature is reached. Sterilizers with a capacity of 6-20 tons/hr are available.8/

6/ Galloway, J.P., op. cit.

7/ Ibid.

8/ Berger, K.G., Production of palm oil from fruit, in: Journal of American Oil Chemists' Society, February 1983, pp. 206-211.

(b) Cracking, dehulling, shelling

Conventionally, soybeans are cracked with corrugated roller mills of 25 cm diameter and 107 cm length. Higher capacities have been achieved with longer rolls and rolls with bigger diameters as well as with cracking rolls of higher rotational speeds. Equipment for separation of hulls from seeds includes, in addition to cracking, corrugated mills, also impact hullers, bar hullers, disc hullers, hammer mills and other machines specifically suited to the raw material. The requirement is to cut the hull so that an optimal separation of meat and hull will take place. Soybeans are usually cut into quarters or eighths. Cottonseed, safflower or sunflower are cut coarsely and usually into halves only, lengthwise or crosswise, depending on the oilseed. Tumbling and shaking separate palm fruits from their stems, mashing of palm fruit in vertical, jacketed cylindrical vats equipped with mixing arms, produces a mash which allows for separation of the pulp from the kernel. Use of hammer mills for size reduction makes a later separation of the hulls or husks impossible and will result in a meal with high fibre content. High fibre meal or low protein meals have their market. This market determines what level of protein or fibre content is required and as a result of this, how much effort and how many repetitive separation steps will be employed in order to achieve the correct final hulls/meats ratio. As an example, cottonseed can yield a 36, 41 or 44 per cent protein meal. Sunflower meal can be produced with 33-46 per cent protein. Hull removal after oil extraction can complement dehulling prior to oil extraction, and hull removal operations are designed to meet changing market demands for meals with protein and fibre contents as required from time to time. Both leading oilseeds, soybeans and cottonseeds can be easily decorticated.[9/]

(c) Flaking (size reduction)

Flaking of oilseeds is accomplished by flaking rolls. These are smooth rolls, one fixed and one rotating. The distance between the two rolls is adjusted. Flake thickness depends on the distance between the rolls, the

---

9/ Galloway, J.P., op. cit.

r.p.m. of the rolls and their weight. Recent development in flaking rolls technology concerns both larger and longer rolls, moving faster than before. This provides for a larger flaking capacity but cannot be achieved without increase in maintenance and wear. Improved distribution of oilseeds along the full length of the rolls and removal of the overflow together with the construction of heavier rolls helps wear reduction. Still final flake thickness depends on what further processing the oilseed flake will be subjected to.

2.2.4 Oil extraction

Both solvent extraction and mechanical presses are used by the vegetable oils and fats industries for the separation of oil from oilseeds. Both small and large, continuous and batch systems are available.

(a) Mechanical oil extraction

Screw presses are used world wide for recovery of oil from oilseeds through the application of pressure. Two approaches and techniques are used. The first is the application of high pressures and subsequent production of low fat content residual meals, and the second is a prepress operation prior to solvent extraction. Seed preparation, seed cooking, screw pressing and recirculation of separated solids from the oil/solids mixture, all influence pressing efficiency. High pressure pressing aims at obtaining the highest oil extraction from the oilseed and the production of a meal with minimum fat content. In prepress operations the combination of oil pressing and solvent extraction aims at overall efficiency. Mechanical oil extraction through pressing needs to take into account the effect of pressure on meal permeability, both in prepressing and in high pressure pressing. The screw press has a main wormshaft equipped with a screw assembly composed of screw and spacer elements. The barrel is equipped with oil drainage and produces a meal (or cake) and crude oil (with some solids). Oil presses with main drive motors are available from 20 h.p. and a capacity (cottonseed) of 5 tons per 24 hours to 600 h.p. with a capacity of 460 tons/day. Several large European and American companies dominate this field of mechanical oil extraction. An

Argentinian and a Brazilian company also manufacture screw presses. Mechanical oil extraction is followed by settling tanks and filter presses for separation of crude oil from solids.10/

(b) Solvent extraction

Solvent extraction can be performed in a batch or a continuous process.

(i) Batch solvent extraction. Batch extraction is usually used for oil recovery from prepressed oilseeds and is usually done in series. The extractor is loaded with raw material and is closed. Then the extractor is filled with solvent. This is done in a cycle with other batch extractors already extracting, so that the meal with the lowest oil content will receive fresh solvent and the unextracted meal will receive the rich miscella. The equipment includes miscellaneous filters, distillation (steam) facilities for solvent removal and solvent recovery.

(ii) Continuous solvent extraction. The extractor is the heart of modern oil extraction operations. It needs to provide for the following: conveyance of solids, solids retention time as required, solvent flow at required volumes, solid-solvent contact, separation of solids from liquid. In the percolation extractor, liquid solvent is pumped through a bed of oilseeds, flakes or meal. The solvent percolates through the bed and leaves at the bottom through a filter, e.g. a mesh screen, etc. Oilseeds or meal and solvent are moved counter-currently with fresh solvent being applied to spent flakes and miscella to fresh feed. Continuous percolation extractors are of the rotary type, chain and basket type, perforated belt type, chain conveyor type or the filter type. Immersion type extractors

---

10/ Bredeson, D.K., Mechanical Oil Extraction, in: Journal of the American Oil Chemists' Society, February 1983, pp. 211-214.

are used for lower capacity applications, with raw materials that tend to disintegrate and form fines or for pigments extraction.11/

2.2.5 Identification of equipment12/

Depending upon the scale and method, equipment in oil milling facilities can be roughly described as shown in figure 1.

Of the various methods diagrammed, the oil in seeds with a high content of oil can be extracted almost completely by the mechanical method of pressing, especially by the continuous press (expeller or screw press). In order to lighten the load of the press, however, there is the prepress solvent process. Direct extraction by solvent would be economical for raw materials such as soybeans which have an oil content of approximately 20 per cent.

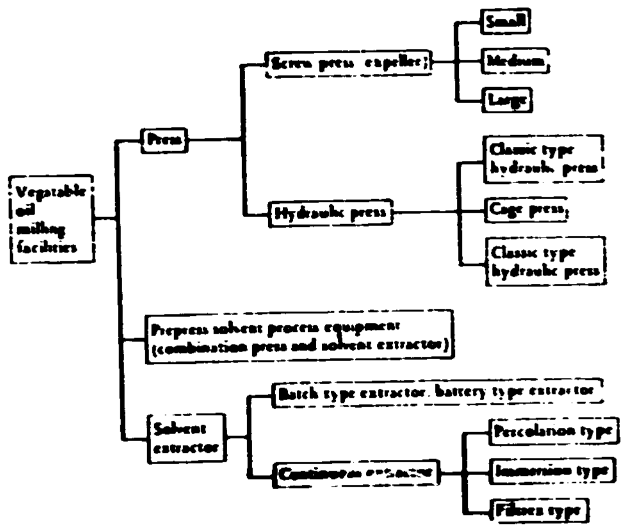
(a) Expeller

The expeller method which is suitable for seeds with a high oil content ranges from large size machines with a driving power of 600 h.p. and a treating capacity of 460 tons/day to portable type machines with a treating capacity of 1 ton/day. Compared with the hydraulic press, such as the cage press, the expeller can work continuously and automatically for labour saving. Double types and two-step types are being manufactured even for small machines; the oil yield has improved and the operation has been simplified (see figure 2).

11/ Bernandini, E., Batch and Continuous Solvent Extraction Equipment, in: Journal of American Chemists' Society, June 1976, pp. 275-278, and Milligan, E.D., Survey of Current Solvent Extraction, in: Journal of American Chemists' Society, pp. 286-290.

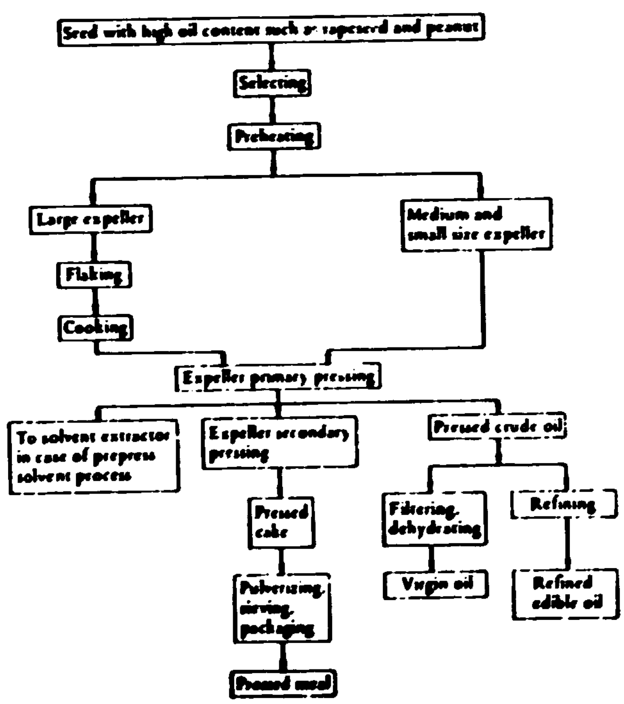
12/ The material presented in this section is taken from: UNIDO, How to Start Manufacturing Industries, Technological and Investment Perspectives, Vienna, 1981.

Figure 1. The vegetable oil milling facilities



<u>Source</u>: UNIDO, How to start manufacturing industry, <u>op. cit</u>.

Figure 2. Flow sheet for pressing process



<u>Source</u>: <u>Ibid</u>.

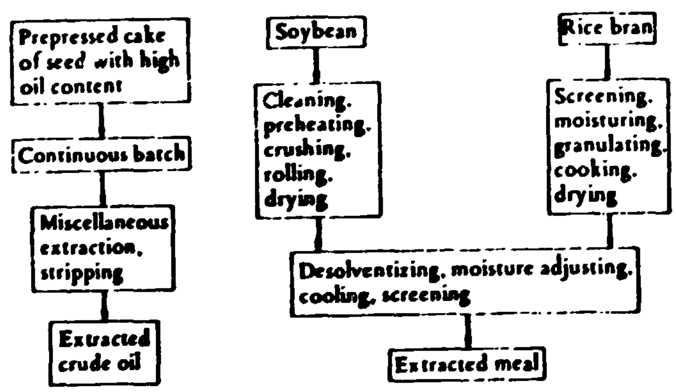
(b) Prepress solvent method oil extraction equipment

The prepress solvent method is carried out in order to reduce the remaining oil in the pressed cake of seed with high oil content to less than one per cent. The oil milling cost, compared to the expeller method, is low. This means that an oil cake is prepared, which has been lightly pressed in the prepress step so that there will be approximately 15 per cent oil remaining, then the remaining oil is completely drawn out in the extraction step. Generally, the remaining oil will be less than one tenth of the oil in the original pressed cake. The quality of crude oil obtained by solvent extraction in the prepress solvent process is generally inferior to crude oil obtained by the press method, and so the oil is not suitable for manufacturing virgin oil. Moreover, the oil becomes edible only after going through the regular refining process. Even for the installation and operation of a small size plant considerable expense is required.

(c) Solvent extractor facilities

A vegetable oil milling plant of ordinary scale usually adopts the solvent extraction process. Soybean, rice bran with low oil content, and the pressed cake of seed with high oil content are mainly extracted by this process (see figure 3).

Figure 3. Flow sheet for solvent extraction process



Source: Ibid.

The batch system, the battery system and the continuous extraction method are examples of extraction methods.

The most simple batch method, which is also called the fixed method, consists of one to four extractors. There is a simplified version for medium and small scale enterprises which is cheap and suitable for intermittent operation.

The battery system has one line of four to eight extractors and is operated semi-continuously. Like the batch system, manual operation of the valve during processing is necessary.

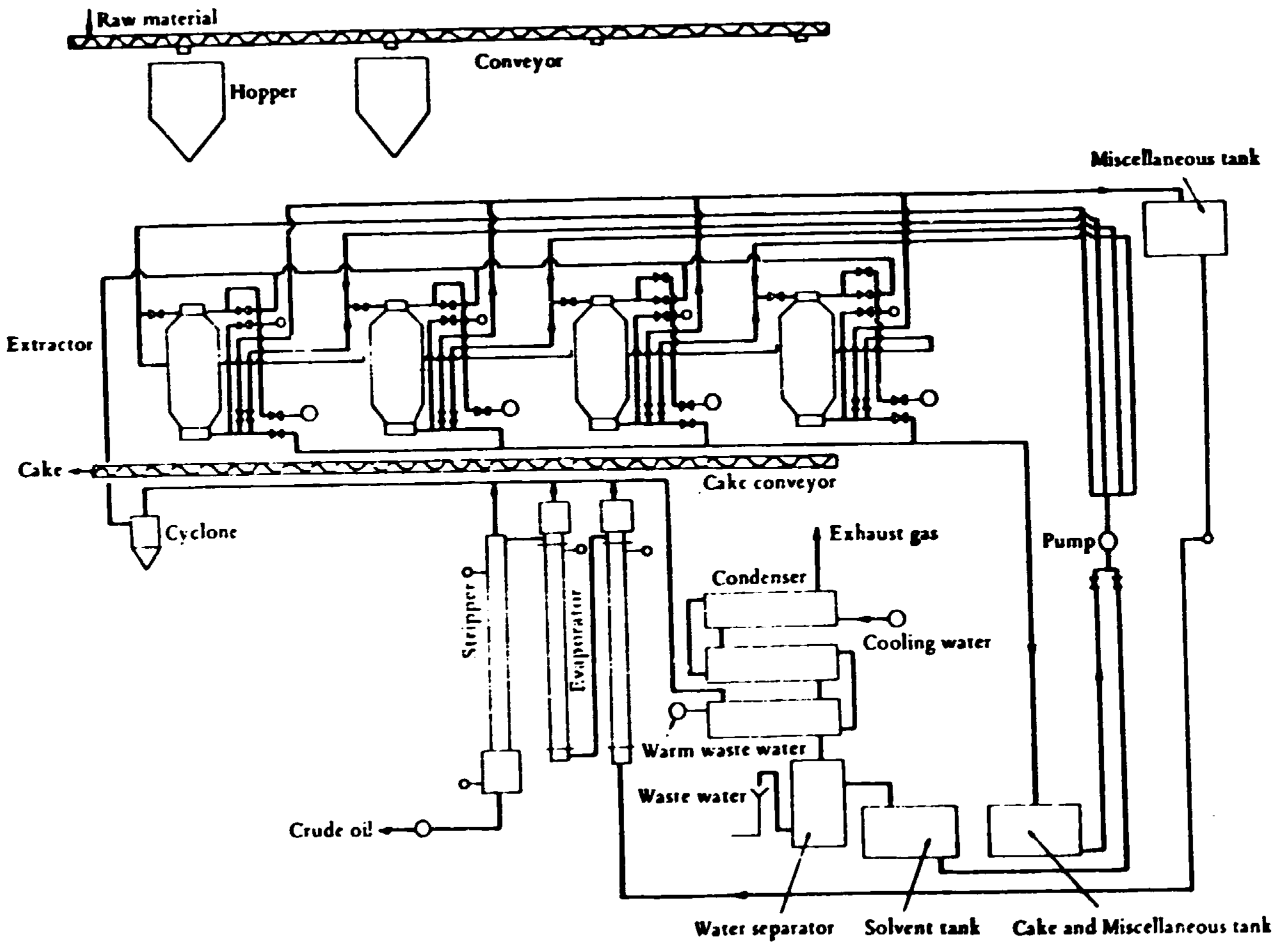
In the continuous extraction method, manual operation of valves during processing is quite unnecessary, and so there is no danger of e.g. an explosion of solvent due to mishandling by the operator. Also labour saving and enlargement of the system become easy - the capacity can be expanded to 4,500 tons/day. The flow sheet of a small size batch plant which has been developed exclusively by Japanese technology and a medium size continuous extractor are given in figure 4.

(d) Refining unit of oil and fat

The crude oil manufactured from the raw materials mentioned above is consumed as virgin oil. It becomes refined edible oil only after going through the refining process, which includes vacuum deodorization. The refining process is shown in figure 5.

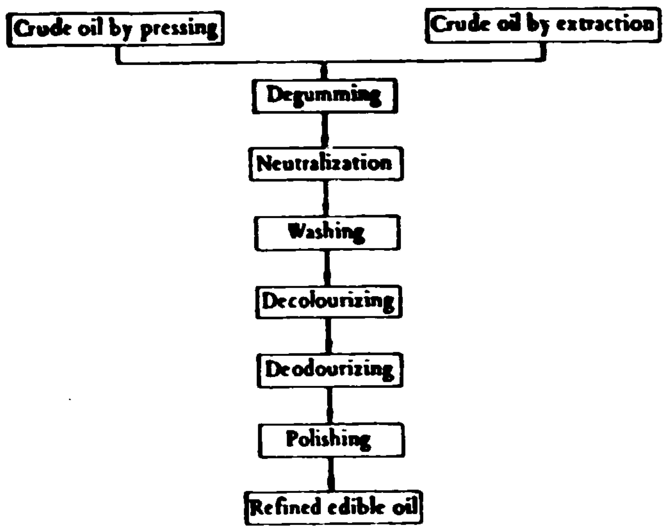
Sometimes the refining process is limited to simple physical treatment such as heating and filtering, but for the refining of superior quality of crude oil generally the oil is separated by centrifuge, decolouration is done by active clay and steam deodorization is also done at high temperature in vacuum up to 5 mmHg.

Figure 4. Process flow sheet for extracting oil, small size batch system



Source: Ibid.

Figure 5. Flow sheet for refining process



Source: Ibid.

2.2.6 Distillation solvent recovery

Solvent is primarily recovered from the miscella and from the oilseed meal. The recovery of the solvent from the miscella is achieved through distillation in steam heated distillation towers. This operation yields crude oil and recovered solvent. The solvent from solvent containing flakes from the extractor is recovered by low pressure steam. Steam condensation requires further drying and cooling of the meal.[13/] Rotary meal dryers and coolers are used for this purpose and the final product is sold as animal feed. Flash solvent systems produce meals with higher protein solubility and nutritional value.

13/ See, Myers, N.W., Solvent Recovery, in: Journal of American Chemists' Society, February 1983, pp. 224-226.

2.2.7 Crude oil treatment

This section refers to crude oil handling and storage, bleaching, degumming, refining, deodorization and dewaxing.

If crude oil deliveries are made to a separate refining plant, storage tanks for crude oil are required. They could be required at both ends of the process and could also be required for operational reasons if oil is both extracted and refined on the same premises. Tanks should be equipped with inlets and outlets which allow for oil deliveries. Storage should prevent penetration of foreign material including water or water vapours through contact with air or with metals like copper, brass etc.

Degumming is achieved by adding water to crude oil. The hydrated phosphatides are insoluble in oil and can be separated by centrifuges. Refining is achieved by use of acid, caustic substances and heat. Mixer, tanks and centrifuges separate oil from soapstock. Refining can be done in a batch or continuous process. Bleaching can be achieved by absorption of pigments by clay, carbon stack or by heating the oil in presses or by absence of oxygen. Deodorization establishes the final flavour and odour of the oil and is achieved through a series of steps in which oil is subjected to heat treatment and stripping at low atmospheric pressure.[14/]

2.2.8 Advances in technology[15/]

An on-going programme of research and development, undertaken largely by equipment manufacturers or sponsored by specific commodity development agencies, ensures that successful research ideas or new materials are gradually converted to practical applications and eventually result in marketed hardware or consumables.

14/ See, Gavin, A.M., Energy Conservation in Edible Oil Processing, in: Journal of American Chemists' Society, February 1983, pp. 420-426.

15/ See, UNIDO, The vegetable oils and fats industry in developing countries: outlook and perspectives, UNIDO/IS.477, pages 136-143.

Of particular note over the past decade or so have been improvements in both the design and operation of machinery aimed at achieving reductions in energy requirements, the more widespread application of fractionation processes to palm oil and the separate marketing of the derived liquid and solid components; and the wider acceptance of physical refining as opposed to the traditional neutralization/bleaching/deodorization sequence.

In soya bean processing, for instance, innovations include new methods of air recirculation of energy efficiency in drying and modified cracking, as well as new equipment for hulling and flaking. The innovations provide energy savings, better particle size control and improved flake yields. A more recent development applies fluid bed technology to dehulling, conditioning and drying.

Improved solvent extraction designs, applicable to many oilseeds, are leading to reduced solvent losses, and more manufacturers are now marketing extractors that physically turn the bed to seed flakes during the solvent cycle, a procedure that is claimed to increase oil extraction efficiency by exposing fresh surfaces to solvent action so reducing channelling, and lessening solvent retention by the deoiled bran. The process should help reduce the energy requirements of solvent extraction.

Palm oil extraction and processing technology has made numerous advances in recent years which have resulted in both better quality standards and an increased range of traded products. Palm fruit specific screw presses have virtually replaced hydraulic presses in all but the very smallest mills and the emphasis on good harvesting routines, rapid undelayed bunch sterilization on receipt at the factory, and improved oil drying equipment have all contributed to the reduced free fatty acid levels found in crude oil from the major producers. The increased use of stainless steel and magnetic traps within the factory has minimized contamination with iron and the consequent oxidation of this oil - a major cause of the traditional bleaching problems. Frequent routine monitoring and analysis ensure the maintenance of high yields and low losses. The development of satisfactory effluent treatment systems has been forced on the industry in many parts of the world by strict pollution control legislation. The introduction of efficient, versatile, fully automated fractionation units, developed specifically for palm oil has greatly enhanced penetration of palm oil products into the cooking oil and solid cooking fat/vanaspati markets, hitherto the domain of the more unsaturated vegetable oils, their hydrogenated derivatives and animal fats.

The basis of physical refining is the operation of a traditional deodorizer at higher temperatures and lower pressure so that steam distillation of both the fatty acids and the flavour volatiles from the oil takes place. By eliminating the caustic neutralization stage the major source of neutral oil loss is avoided, capital and operating costs are reduced and soap stock treatment - with the attendant pollution problems - is unnecessary since the fatty acids are recovered directly. To be successful, however, the input oil has to be virtually free of the phosphatides (gums), trace metals and pigments which cause darkening of the oil at the high temperatures employed. Development of physical refining has therefore stimulated improvements in pretreatment degumming, bleaching and, in some cases, dewaxing - improvements which have also been of value in conventional refining procedures. Although initially developed to deal with high levels of free fatty acid in the oils (about 5 per cent ffa), at which level losses during caustic refining become very significant, physical refining has now become the preferred method for all qualities of palm oil. It is also increasingly used for coconut oil and has been successfully applied to maize and sunflower oils. Soya bean and rapeseed oils still present problems due to phosphatide and pigment contents but work is proceeding to develop pretreatment procedures so that refining by the physical route will become possible.

Improvements in expeller design have included the introduction of harder wearing components to reduce maintenance schedules. Manufacturers' model ranges have been extended at both large and small throughput levels and work has been carried out on the development of pre-press expellers which eliminate the need for the other traditional conditioning steps - cooking, rolling, flaking - which are normally required as a pre-requisite for solvent extraction. These developments allow very substantial energy economies. Conventional edible oil processing is turning rapidly away from batch operation and towards continuous refining procedures. Greater use can then be made of centrifuges and self-cleaning filters for such steps as degumming, dewaxing, water washing, the removal of spent bleaching earth, hydrogenation catalyst and soap stock. Clarification/polishing steps are conventionally carried out by sedimentation of plate/frame filtration. Speedier processing and enhanced yields are the major aim for such innovations but the automation that becomes possible with the introduction of such equipment also reduces labour requirements.

With oil palm, fibre by-products (sometimes together with kernels - although these are now almost invariably recovered) have always been used as fuel for the boiler to power the factory. Other oilseed by-products such as sunflower shells, cottonseed hulls and groundnut husks can be similarly used as a result of multi-fuel boiler development, clearly greatly reducing petroleum fuel requirements.

The technological aspects of acqueous coconut processing using fresh coconut meat, which aims at avoiding the quality deterioration of both oil and protein that invariably accompanies copra manufacture, has been intensively examined and much progress made over the past few years. A pilot plant employing the most appropriate comminuting, extraction, separation and drying equipment has been assembled in a USAID funded project in the Philippines and the yield and quality characteristics of a wide range of products - coconut milk, coconut cream, coconut oil, coconut skim milk powder and a variety of protein and fibre products - evaluated and documented. Doubts, however, still remain on the economics of the process. The increase in revenues obtained by using the process as a source of edible oil is largely due to the higher value of the better quality oil, but it is not sufficient to outweigh the substantial increase in capital costs compared with conventional copra crushing. However, if a high value market can be found or developed for the edible grade protein products, wet processing may become economically viable. Until this is achieved, copra crushing will remain the preferred source of coconut oil.

The market for groundnut cake has continued to be influenced by fear of aflatoxin contamination (a toxic metabolite produced by the mould *Aspergillus flavus*).

Consequently many countries severely limit the level of groundnut cake in livestock feed or even prohibit the importation of the commodity entirely. Despite many years of research and development no detoxification procedure has, at the time of writing, been universally accepted but recent investigations into ammoniation technology show great promise. The problem may well be significantly reduced in the not too distant future when appropriate equipment becomes commercially available.

Oilseeds handling and processing technologies, including extraction, solvent recovery, distillation, deodorization, keep developing. New energy saving techniques are developed and employed. Some of these are mentioned in this section.

Extrusion, as pretreatment of oilseeds prior to oil extraction can increase the efficiency of the solvent extractor and can affect the solvent/oil ratio. This in turn influences the energy balance of the operation. With less solvent to unit oil produced, energy is saved. Equipment can be smaller, or higher capacities can be achieved with the same equipment. Extrusion cooking produces densified soy or other oilseed and brings about these improvements.

A process which achieves a higher capacity through increase of bulk density of soybean flakes, not through the enhancer but through a long term low temperature and moisture process, was recently developed. This process which starts with soybean flakes which pass through a process of steam injection and agglomeration, influences not only the efficiency of extraction, but can also strongly affect the phosphatide situation in the raw material. It renders the soybean oil phosphatides water soluble enough to permit mechanical refining and makes chemical refining unnecessary. This represents considerable savings. Lecithin recovery can increase by as much as 100 per cent.[16/]

16/ See, Kock, M., Basis for a quality improvement of soybean oil by treatment of the soya flakes prior to extraction, paper presented at 36 DGF Vortragstagung, Kiel, Federal Republic of Germany, September 1980.

Changes take place in the oil industry in several fields:

(a) Automation

The degree of automation in the oil/fats industry is increasing, both in new and in old plants. Microchips based instrumentation systems and micro processors already control and run fully automated soybean oil extraction and refining plants. Where process control is employed, the operator uses process conditions signalled to him in order to optimize unit operations. By using modern micro electronic based control systems it is possible to move to production control. The data originating from process control will be used by computerized systems in order to make operational decisions. This will lead to improved safety, energy conservation, consistent product quality and less labour costs.[17/]

(b) Physical refining

Increased efficiency of equipment use, higher yield of phosphatides and energy saving have been developed. Simplicity in operation and elimination of the recycling of caustic soda are important benefits.[18/]

(c) Fluidbed technology

This technology has now been introduced to oil extraction and is employed in the conditioning of cracked beans, dehulling, drying and in cooling. This technology provides for an improved heat and mass transfer and results in energy savings of up to 50 per cent.

17/ See, Duff, A.J., Automation in Vegetable Oil Refineries, in: Journal of American Chemists' Society, June 1976, pp. 370-381 and Jokinen, K., Sakko, J. and Stenlund, L., Automation in a Vegetable Oil Extraction Plant, in: Journal of American Chemists' Society, February 1983, pp. 436-443.

18/ Kock, M., op. cit.

2.3 Cereal grain milling processing technologies

2.3.1 General

Wheat, rice and maize are the most important cereals. Although usually there is more rice and maize produced in the developing countries as these cereals have been a traditional source of nutrition, consumption of wheat and pressures to increase wheat and wheat products availability is constantly growing. Wheat milling today involves usually large, automated and sophisticated plants. The same applies to maize processing when well identified substreams of maize kernel products are produced. Core capital goods for these industries are manufactured by a limited number of international companies which own the patent rights or the technological know-how. Peripheral capital goods for these industries can be manufactured in the developing countries, however, big new grain milling projects are few. Rice processing is different and requires technology which can lend itself to the development of local core and peripheral capital goods industry in the developing countries.[19/]

2.3.2 Wheat milling

Wheat as delivered from the field contains different types of impurities which need to be removed prior to storage.

(a) Wheat dry cleaning

Impurities delivered with the wheat are of different sizes, shapes and bulk density. Machines which have been developed for the removal of these impurities basically employ sieves and air currents or discs or cylinders with special indentations. Scourers with perforated or abrasive cylindrical casings, with beaters installed inside, are used. Soil fungi are removed by

---

19/ See, Mackey, J., Cereals Production, in: Cereals, a Renewable Resources, Pomeranz, Y., and Munk, L., (eds.), American Association of Cereal Chemists, 1981, p. 5; and Pomeranz, Y., Wheat, Chemistry and Technology, 1978.

the action of these beaters. Air currents are used in aspirators and pneumatic conveying is used to remove impurities from grain. Together with impurities, badly shrivelled or weather damaged wheat is also removed.

(b) Wheat drying

Prior to storage and upon delivery, wheat and/or other grains have to be dried so that they contain the appropriate level of moisture. This moisture content needs to be conducive to safe storage. The removal of moisture is achieved usually by employing grain dryers which are manufactured in many different sizes. Large grain dryers are designed as multi stage dryers of several sections including a cooling section. The moist grain enters from the top of the drying column and advances towards the bottom in a zig-zag fashion. The heating is usually direct by means of a liquid fuel burner with controlled temperature and flame. Air circulated in the cooling stage can be recovered and used as input air to the dryer as an energy saving feature. Small grain dryers are fairly simple installations to construct, maintain or operate.

(c) Transport and storage

The silo consists of several cells, constructed with panels of corrugated galvanized steel sheets, which impart great rigidity to the walls. The thickness of the steel sheets varies with the diameter and height. In order to give the necessary vertical rigidity the cell has internal stanchions made from steel sheet, which have been galvanized in their last stage of manufacture. The joints between the panels or with the stanchions are made by means of galvanized steel or chrome plated bolts. The roofs are made from galvanized sheet sections, the shape of which has been designed with the double purpose of ensuring rigidity and watertightness. The silo in itself presents no special construction problems, its design is mainly a matter of strength of materials and structural calculations.

(d) Wheat conditioning (cold, warm, hot)

Wheat conditioning is the step during which water is added to wheat prior to milling. While addition of moisture helps the separation of bran from endosperm, excess moisture does not facilitate the sifting of milled wheat. A compromise is normally sought for the optimum level of moisture addition. The equipment for wheat conditioning is usually rather simple and involves screw conveyors with water addition.

(e) Milling

Milling systems include mills, sieves, conveyors, cyclones, filters, feed locks and pneumatic systems.

Cylinder mills. The supporting frame is of cast iron, usually in one piece. This can be produced by well equipped shops with high quality standards. The cylinders, which are of centrifugally cast iron, need to be of very high quality. They are supported by oscillating ballbearings. Little maintenance is required.

Impact and disintegrating machines. This type of equipment may be of simple construction, still it calls for great precision. The purpose of these machines is to increase the percentage of fine flour and to disintegrate any flakes which may form in the mill, especially with products which contain bran.

The other key pieces of equipment in the production of high quality flour are the sieves. A series of machines capable of screening and of separating the by-products of milling to different size ranges are grouped under this heading. Flat sieves are used to classify the products coming from the crushing rolls and mills according to size. They are capable of carrying out eight separations per compartment and are therefore very versatile. The sieves, faced with anti-abrasive laminated plastic, facilitate rapid change of output.

Construction of such equipment is limited to companies which own this know-how and expertise or can obtain it through co-operation.

Screens are basically two rows of sieves which complete the operations of the horizontal sieves. Flour with much reduced fines can be produced. The technological and construction considerations are the same as those mentioned for horizontal sieves.

2.3.3 Rice milling

Threshed and dry paddy is delivered from the field. It is only suitable for human consumption after dehusking. Once dehusking is accomplished and the bran removed, rice grains, high in carbohydrates and low in proteins, remain. Threshed and dried paddy can be converted to dehusked, debranned rice or through a parboiling step to a parboiled, dehusked and debranned rice. The removed husks can be used as fuel, the bran, which also can be stored, is usually used as an animal feed or as a source of rice bran oil.

The paddy brought in is conveyed to the paddy cleaner by a bucket elevator.[20/] The cleaner is designed to remove straw dust, pebbles, etc. to enhance the value of the rice as well as to prevent malfunction of the following processes. The clean paddy thus obtained is then carried into a paddy husker. This paddy husker consists of a husking chamber and an aspirator to separate husked rice and husks.

The separated paddy is again returned to the paddy husker for rehusking. Meanwhile, the husked rice is moved into the whitening machine consisting of a combination of 3 or 5 units of abrasive rollers and friction type machines.

How to combine these units is decided by the shape, quality and other characteristics of the rice. The bran produced by this equipment is collected at one place by a suction fan. The whitened rice is conveyed to a rice refining machine for refining and further removing of bran. The next process is sieving with an aspirator in order to remove bran completely by air current

---

20/ The material of this section is taken from: UNIDO, How to start manufacturing industries, op. cit.

and separate small pieces of broken rice mixed in the whitened rice. The whitened rice is fed into the subsequent process to be divided into whole rice, large broken rice and small broken rice so as to be suitable for marketing. Then the rice is stored in tanks and weighed and packed in bags for shipping (see figure 6).

(a) Rice cleaning

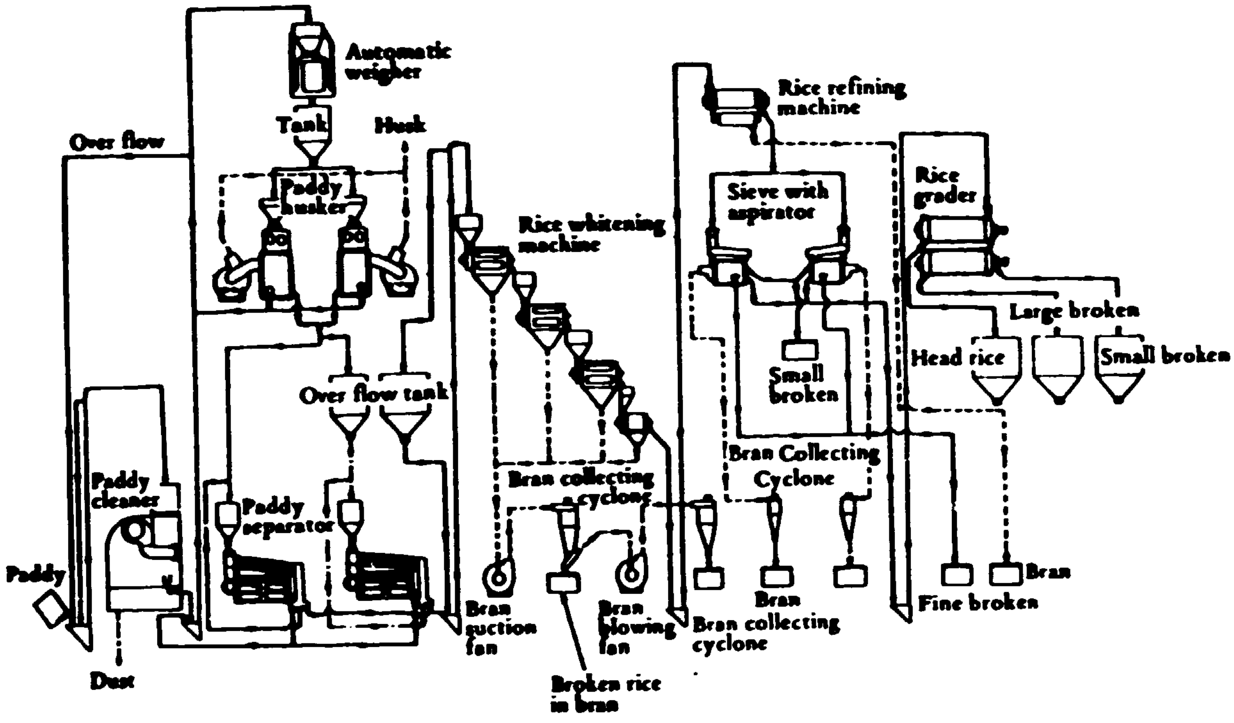
Rice cleaning installations, large or small, are simple. They include cylindrical or horizontal rotating or vibrating screens with aspirators, magnets and means for separating stones, sand, metals, field refuse etc. Cleaned rice can further be processed into parboiled rice, or can be dehusked and debranned without parboiling.

(b) Parboiling

A considerable portion of the rice produced annually throughout the world is parboiled. Estimates are between 20 and 25 per cent. The process involves submerging the threshed paddy in water and heating. During parboiling, rice starch gelatinizes, active enzymes are deactivated completely or partially, and other important chemical changes occur, which contribute to a higher milling yield and quality of milled parboiled rice. Parboiled paddy and parboiled milled rice keep longer. The grain remains firmer during cooking and absorbs more moisture and less fat.

First the paddy is submerged in water in metal or concrete tanks. This steeping takes up to 60 hours. After drainage, the rice is heated by steam injection i.e. placed in steaming vats or by open pan tempering. Heating can take place in continuous equipment equipped with pressurized valves. Parboiled rice can be sun dried or dried by rotary dryers, grain dryers or others. Pans for parboiling are made of hemispherically-shaped steel sheets, welded with a supporting frame of steel profiles. Parboiling can be done also on double-bottom steam heated pans; in this case husks can be used for firing steam generators. A more complex technology employs autoclaves, steam heated and pressurized, rotating on an horizontal axis. Small grain dryers are normally of the column type, where grain falls in countercurrent with hot air,

Figure 6. Process flow sheet for rice milling plant



Source: UNIDO, How to start manufacturing industry, op. cit.

following a zig-zag path. Air is heated by an exchanger and propelled by a fan. A more complex technology employs vacuum dryers. Manufacturing of pans and small dryers calls for metal sheet forming and welding and for some machining, the grade of complexity is low.

Larger rice mills use integrated parboiling equipment, with the same rotating autoclaves for soaking (steam heated) and drying (vacuum effected); this machinery is very complex and fully automated.[21/]

(c) Milling

Milling of rice, parboiled or non-parboiled includes both husk and bran removal. The rubber roller dehuller consists of two closely spaced rubber rollers, rotating in opposite directions and at different speeds. They are driven by a gear box and supported by ball bearings. A steel profile or cast iron frame supports moving parts. Rubber rollers are subjected to considerable wear and have to be frequently changed. Distance between rollers may be adjusted.

Bran removal is obtained by abrasive cones. This is basically a cast iron cone, with an abrasive external coating. The cone revolves in an aluminium or steel casing where metal mesh or perforated sheet sections remove bran, while rubber bars retain whitened rice. The abrasive action of the cone can be adjusted by moving the cone vertically. A steel or cast iron frame is the machine body, where the cone is supported by ball bearings and driven by pulleys and shafts. Cone whiteners can be considered as intermediate technology machines and their manufacturing requires a higher degree of mechanical machining and cast iron forming.

21/ See, Gariboldi, F., Rice Parboiling, FAO Agricultural Development Paper No. 97, Rome 1974.

2.3.4 Maize (corn) milling

Wet milling of corn which results in the separation of the corn into hull, germ, starch and gluten will not be a subject for discussion here. The dry milling of corn involves the following approaches:

(i) Reduction in size through dry grinding;
(ii) The tempering degerming system;
(iii) The dry degerming system.

Prior to milling, the corn is cleaned and stored. Cleaning of grain has been discussed already in this report.

(a) Dry grinding

This process includes the use of hammer mills and stone mills. Hammer mills have a rotating shaft supported by ball bearings. The shaft supports several arms and hammer heads. A large variety of shapes and sizes exists. Rotating hammers force the material to be ground against rotors which permit only particles of a certain size or smaller to escape. Stone mills with one stone or both stones rotating, driven by an electric motor or diesel engine are also used to grind dry corn. Manufacturing of hammer mills calls for casting of the body of the mill and that of the rotating arms, welding of sheets and profiles and machinings of operating and rotating parts. Manufacture of stone grinders requires a similar capability.[22/]

(b) Tempering degerming

Moisture is added to the corn in the form of cold water, hot water or steam in required quantities depending on the properties of the corn. Presoaking is done in vats, tanks or reservoirs or in screw conveyors. Soaking time determines the size of presoaking installations. Degerming is

---

22/ See, Shukla, P.T., Industrial Uses of Dry Milled Corn Products, in Pomeranz, Y., and Munt, L. (eds.), op. cit. p. 489.

usually achieved in 2 steps. In the first step, a degermer stock is produced. This is a mixture of endosperm, grits, hulls and germs. The degermer and corn huller is an attrition device built as a cone mill. The cone shaped rotor is mounted on a rotating, horizontal shaft in a conical cage. The cone has protrusions over most of its surface. The Beall degermer is the most used degermer in the United States. Degerminators of this kind are built in different sizes, with the most popular driven by a 50 H.P. motor and processing up to 2.5-3.0 tons of corn per hour. Depending on moisture content, drying and cooling may be required (down to 15-18 per cent moisture level). This is followed by rolling and grading.

The recovery of various primary products is accomplished on corrugated roller mills. Each pair of rolls is selected according to different mill steam. Sifting is an important operation. Aspirators are used extensively to separate and recover hull fragments. Corrugated rolls are used in the roller mills. Each separation step consists of an aspirator, a roller mill and a sifter. Separation occurs in a long, rapidly oscillating sieve clothed by a series of fabrics having progressively larger openings towards the tail end. This (gravity table) separator classifies particles according to differences in density and aerodynamic properties. The different products produced by this separator is later on milled further.

Screw conveyors and bucket elevators are used extensively for material transport in the mill. Pneumatic conveying systems are gaining popularity now, since they occupy less space, are easier to maintain and are more sanitary.

(c) Dry degerming

Degerming and dehulling of untempered corn can be achieved through processes and equipment developed for this purpose by the Miag or Ocrim companies. In both processes, corn with 12 to 16 per cent moisture is processed in an impact type machine, vertical or horizontal and separation based on size and density takes place with sifters, aspirators and table separators. This specialized technology is supplied through its owners or their subsidiaries.

2.4 Consideration of plant size

A comparison of the activities in the vegetable oil crushing industry in the United States in 1982 with those in 1977 shows that the number of factories have decreased from 260 to 233, i.e. a decrease of slightly over 10 per cent. At the same time, total oilseeds processed rose from around 23 million tons to approximately 42 million tons, an increase of approximately 85 per cent. Those figures point to a trend in the United States and in other developed countries to have fewer but larger plants.[23/]

Large plants both require and justify higher levels of automation and process control. Often, large factories are highly specialized and can handle different raw materials with less flexibility than small ones. Simple equipment for oil crushing and for small-scale processing of vegetable oil is available. Consideration of funds for investment, infrastructure as well as economies of scale, absolute amount of investment, operation costs per unit of output will also determine the size of the oil extraction plant. An oilseed crushing and refining plant with a capacity of 50 to 250 tons of oilseeds per 24 hours or less is considered a small plant.

Leading manufacturers and suppliers of vegetable oil extraction and processing equipment are capable of supplying complete plants or processing systems for small and large plants, either by delivery of equipment or on a turn-key basis. This is done with or without local suppliers for peripheral or non critical equipment.

In modern grain milling suppliers may base a large size operation on a repetition of smaller lines. This in a sense will make a large plant basically a combination of several smaller ones without very much changing the problem of local production of core or peripheral capital goods.

23/ See, U.S. Crushing Trends, in: Journal of American Chemists' Society, vol. 62, page 480, 1985.

2.5 Technology for energy saving

A continuous effort is being made, usually by equipment manufacturers, to develop systems and processes that will result in saving of energy in the process of extraction and processing of vegetable oils. This is due to the fact that energy has become much more expensive than before, and that following this increase in energy costs, almost all other inputs have gone up in price as well. This situation makes it all the more necessary to cut down on processing costs and there again, the cost of energy becomes a target for reduction.

Steam consumption per metric ton of processed soybeans from beans to desolventized, dried meal and degummed oil was until 1950 approximately 405kg. In the early 1980s it was approximately 330kg, and a level of 177kg is considered reachable.[24/] This can possibly be achieved by redesigning of some equipment systems although better management of equipment and utilities and improved maintenance can still play an even more important role. Considerable energy savings can be realized by introducing more heat recovery systems and by developing and utilizing multi fuel systems.[25/]

Considerable savings of energy can be achieved if the process includes a cold prepressing step. When compared with the classical process, which requires crushing, milling and cooking prior to prepressing, or with the direct extraction process which requires crushing, flaking and granulation, the cold prepressing requires significantly less energy. This process is optimally suitable for factories with a capacity of 300 tons/day of raw materials. Additional technological innovations, like extraction under pressure, precooking and agglomeration etc., result in a continuous reduction in energy consumption.[26/]

24/ See, Bolling, H., Milling of Cereals for Total Utilization Resource, in: Pomeranz, Y. (eds.), op. cit., pp. 137-144.

25/ Gavin, A.M., op. cit.

26/ See, Schumacher, H., Ultimate Energy Possibilities in Conventional Solvent Extraction, in: Journal of American Oil Chemists' Society, June 1976, pp. 417-419, Koch, M. op. cit.

The wheat milling industry requires very small amounts of energy when compared to other sub-sectors of the food industry. Yet large mills with extensive pneumatic conveyance systems require around 75 KwH/ton of ground wheat while mills with short conveying tracks may require as little as 55 KwH/ton. In small mills energy requirements are high and may reach 80 KwH/ton. While energy requirements for milling did not change much over the last 3-4 decades, phases other than grinding, and primarily cleaning operations show a large decrease in energy consumption. Although the contribution of the wheat milling industry to national energy saving is very small, still to the individual miller it can be significant. It is believed that in wheat milling this can be achieved through better management.

Modern, automated or controlled systems for rice parboiling represent considerable energy savings when compared with traditional parboiling techniques.

2.6 Core and peripheral capital goods

2.6.1 Core and peripheral capital goods in the oilseeds processing industry

(a) Peripheral capital goods

Pumps
Electrical motors
Electrical motors (explosion)
Control panels
Steam boilers
Steam generators
Heat exchangers
Water coolers
Conveyers: belt, screw, chain, drag, bucket
Negative and positive air transport systems: cyclones, air compresses, tubing
Hoppers
Tanks
Tubes
Settling tanks
Seed conditioners
Magnet cleaners
Aspirators
Storage tanks (liquids)
Weighing systems
Storage installations (oilseeds)
Fork lift trucks
Sifters

(b) Core capital goods

Shakers
Sifters, sieves
Cleaners
Autoclaves
Mixers
Beaters
Cracking rolls
Flaking rolls
Oil seed (grain) dryers
Screw presses
Centrifuges
Distillation columns

Batch extractors
Continuous extractors
Filter presses
Filters
Grinders
Evaporators
Steam ejectors
Meal dryers
Meal coolers

2.6.2 Core and peripheral capital goods in the grain milling industry

(a) Peripheral capital goods

Pumps
Electrical motors
Control panels
Steam boilers
Steam generators
Tanks
Conveyors: belts, screw, chain, drag, bucket
Negative and positive air transport system: cyclones
Air compressors, tubings
Tubes
Bagging equipment
Bins
Stalk strippers
Hoists
Hoppers
Aspirators
Weighing systems
Storage installations (grain)
Fork lift trucks
Magnet cleaners

(b) Core capital goods

Grinding equipment: stone grinders, hammer mills
Grain dryers
Coolers
Grinding rolls
Sifters
Separators
Pans
Rubber rollers
Sieves
Steel rollers
Abrasive cones
Bleachers
Degermers

Level of complexity (L.2)

Peripheral	Core
Tanks	
Bins	
Hoppers	

2.7 Preliminary identification of equipment or production lines that could be produced in developing countries

The level of development of the local metal-working industry will determine its capability to produce machines or production lines of the types reviewed earlier. For the purpose of a preliminary identification, four levels of development of the metalworking industry have been taken arbitrarily and are represented as follows:

Level 1:

On this level are those countries that have a large metal-working industrial base. All machinery or almost all machinery required for vegetable oils crushing and refining and cereal grain milling can be produced nationally. Exceptions would be few. Possibly, grooved mill rolls for wheat milling, advanced and semi-advanced automation equipment need to be imported.

Level 2:

In countries of this level there might be some constraints in securing electrical motors of local construction, if motors of more than 20 kW are required. Intricate electrical control panels may not be secured locally. Complete grain dryers will require importation.

Level 3:

In countries of this level sheet metal work, welding and simple peripheral equipment can be manufactured locally but not very much more than that. Manufacturing drawings must be supplied and an appreciable level of complexity in production of simple machinery requires imported expertise.

Level 4:

Only very minimal technical capability is available locally.

In order to make a preliminary identification of equipment or production lines that could be produced in the developing countries there is a need to take into account many factors. Some of these will be discussed in chapter 3. In Level 1 countries like Brazil, India, all equipment required for the vegetable oil and fats and for the grain milling industry can be and much of it is already being produced. This applies to the capital goods required for the oil and fats and grain milling industries together, or separately.

Level 2 countries with a development level similar to that of Colombia, could manufacture much of the capital goods required for the vegetable oil and for the grain milling industry. There are several exceptions and some core capital goods may require importation. It may not be the problem of lack of local production or production capability of many peripheral and core goods but lack of engineering capabilities. These goods could be produced by a number of local suppliers. Local engineering services would be required, first in order to be familiar with the availablility of capital goods of national origin and then to be capable of incorporating all the capital goods required including those requiring importation into an economical and reliable production line.

An interesting case worth mentioning is that of the establishment in Colombia of a plant for production of precooked maize flour. Rather than proceed on a turn-key basis, a local engineering group has studied the availability of core and peripheral capital goods locally and of national origin. With the exception of a cooking column, centrifugal separator and gravity separation table, which were ordered from abroad, almost all the rest of the capital goods were secured from 3 major and several minor local suppliers. The value of the imported capital goods came to about 30 per cent of the total cost, the equipment and capital goods manufactured locally amounted to close to 70 per cent.

Level 3 countries require importation of all core and peripheral capital goods. In level 4 countries, capabilites are even lower and are almost non-existent as far as construction of core or peripheral capital goods are concerned. The concept of having a national construction of capital goods for the vegetable oil and the grain milling industries may not be an achievable goal and may in the case of many single countries not even be an optimal one.

A basic list of equipment which could represent a production target for the developing countries of levels 3 and 4, and which countries of level 1 and level 2 are already producing or are capable of producing, is the following:

Peripheral capital goods	Core capital goods
Pumps (some)	Grain dryers
Electrical motors (some)	Batch extractors
Electrical motors explosion-proof (some)	
Control panels (some)	
Tanks, settling tanks	
Magnet cleaners	
Air compressors	
Aspirators	
Conveyors (some)	
Cyclones	
Hoppers	
Liquid storage tanks	
Bagging equipment	
Bins	

2.7.1 Core and peripheral capital goods in the oilseeds processing industry according to the complexity criteria

Level of complexity (L.4):

Peripheral	Core	
Control pannels	Autoclaves	Centrifuges
Fork lift trucks	Mixers	Distillation columns
Weighing systems	Grinders	Evaporators
Storage installations	Continuous extractors	Meal dryers
Pumps	Cracking rolls	Meal coolers
	Flaking rolls	Oilseed (grain dryer)
	Screw presses	

Level of complexity (L.3):

Peripheral	Core
Pumps	Shakers
Motors	Sifters, sieves
Steam boilers	Cleaners
Steam generators	Beaters
Heat exchanges	Batch extractors
Water coolers	Filter presses
Conveyors	Filters
Air transport systems, cyclones	Grinders
Air compressors, tubings	Oilseed (grain) dryers
Aspirators	
Storage tanks	
Tanks	
Tubes	
Settling tanks	
Seed conditioners	
Magnet cleaners	

Level of complexity (L.2)

Peripheral	Core
Tanks	
Hoppers	
Containers	

2.7.2 Core and peripheral capital goods in the grain milling industry according to the complexity criteria

Level of complexity (L.4)

Peripheral	Core
Pumps	Grinders
Electrical motors	Hammer mills
Control panels	Grain dryers
Steam boilers	Coolers
Steam generators	Grinding rolls
Forklift trucks	Degermers
Weighing systems	Rubber rollers
Storage installations	Steel rollers
Aspirators	
Bagging equipment	

Level of complexity (L.3)

Peripheral	Core
Conveyors	Sieves
Negative and positive air transport systems, cyclones	Pans
Storage installations	Bleachers
Bins	Separators
Hoists	
Hoppers	

3. BASIC PROBLEMS AND ISSUES AFFECTING THE DEVELOPMENT OF THE CAPITAL GOODS INDUSTRY IN THE OILSEEDS PROCESSING AND GRAIN MILLING INDUSTRIES IN DEVELOPING COUNTRIES

3.1 General

The technology/equipment package of the capital goods in the oilseeds processing and grain milling industries, although readily available, belongs to a rather small number of experienced manufacturing companies. This package underwent constant improvements in design and function and continues to do so. The production of capital goods in this particular field by inexperienced companies is extremely difficult and may fail when the required detailed information on materials, design and special manufacturing techniques are not available. International co-operation will, therefore, have to be sought in all the aspects involved.

A relatively small number of manufacturers of capital goods for the grain milling and oilseeds processing dominate the international scene. These companies operate usually in one of the ways described below:

(a) Enterprise operates predominantly in the country of origin, carrying out exports to foreign customers.

(b) Enterprise is involved in some manufacturing in recipient country/ies in order to serve a country or a sub-geographic region.

(c) Enterprise seeks and finds local groups with whom to co-operate, usually contract out, with supply of technology.

As a result of this, many suppliers of capital goods for the grain milling and the oilseeds processing industry have established a manufacturing base in several developing countries and could expand production of their machinery there, provided they are encouraged to do so and find that conditions are condusive to such activity.

Core and peripheral capital goods are required in the developing countries for the extension and renovation of existing oilseeds processing and grain milling installations. Such capital goods are required as well for setting up of new processing facilities. Local production of all or some of these capital goods could contribute to the economy of the developing countries in several important ways:

- It reduces the foreign exchange component of the investment in the project
- It generates employment and income in the local machine building industry
- It starts or adds force to an on-going process of economical development which would bring about an overall improvement in employment, education, income, etc.

In order to reap such benefits it is necessary that certain conditions are met, so that a sound basis for the establishment or promotion of a local machine building industry in the developing countries is created. The machine building industry should concern itself with the production of peripheral capital goods for the grain milling industry and the oilseeds processing industry. Still, some of the comments made in this report can be extended to the food processing machinery manufacturing industry as a whole.

Among the factors that could directly influence the development of the manufacturing industry of capital goods for the food industry the following could be mentioned:

(a) Demand and competition;
(b) The structure of production of equipment in the food processing industry;
(c) Know-how, engineering services, technical services;
(d) Manufacturing capabilities;
(e) Promotional policies.

These subjects will be treated separately below, within the context of the oilseeds and grain milling industries and also in a more general way. It should be emphasized that these factors are not listed in the order of their absolute importance. These factors may have different relative importance at different times or in different places. They are usually interrelated and will affect one another.

3.2 Demand and competition

The fact that demand for both core and peripheral capital goods for food processing exists in each and every country around the globe does in itself not guarantee that all countries could provide an equally encouraging environment to a capital goods manufacturing industry. When permitted to develop and grow over the years in the developed countries, this industry tended to concentrate and/or expand as a result of market pressures, marketing opportunities and the drive of motivated individuals.

Making investments in setting up a capital goods manufacturing industry requires the study of marketing potential. This market study could relate to the national, sub-regional, regional or international markets. It would relate to capital goods required by only one type of industry or capital goods required by more than one type of industry. As an example, a capital goods manufacturing operation could become specialized in the manufacture of conveyors of different types and for different industries. By comparison, a manufacturer may decide to produce just one type of a dryer which may be used to dry one or more types of product.

In some parts of the world the grain milling industry is milling at a level of production which is determined by the size of local grain crops together with that of imported grain. However frequently in developing countries grain consumption per capita is low because of lack of purchasing power and part of the grain milling industry capacity is not utilized. Careful projection of the possible future growth in milled grain products in each country is, therefore, necessary for the determination of that country's future demand for capital goods for the grain milling industry.

The case of the oil processing industry is similar. Many developing countries encounter shortages of vegetable oils. An evaluation of the size of the market for additional supplies of vegetable oils could be the basis for projecting the possible growth of this industry. Planning of this sub-sector includes forecasts of supplies of oil bearing raw materials from national origin or through importation.

The opportunities in manufacturing of peripheral capital goods should be considered regardless of the opportunities for the setting up of manufacturing facilities for core capital goods for the grain milling and for the oil seed processing industries. Peripheral capital goods requirements for additional sub-sectors of the food and feed industry could strengthen the position of the food industry peripheral capital goods manufacturing industry through a wider range of required products which will provide for a wider manufacturing base.

Investment in core or peripheral equipment in the grain milling and in the oil seed processing industries, as well as in other sub-sectors of the food processing industry involves taking different types of risks. Selection of equipment suppliers is sometimes a lengthy and delicate process in which many factors are being evaluated. A local national manufacturer of core or peripheral capital goods will have to establish a name for itself first, so that when the opportunity arises it will be contacted and/or considered. Foreign constructors of capital goods with or without a manufacturing base in the developed country, with or even without an active representative, are usually quite well known by planners and promoters of industrial development. They are usually contacted and brought into the picture primarily because of the reliability of their products and of their services.

Both core and peripheral capital goods are required to provide a reliable service. Production problems can occur with both types. Solving production problems of core capital goods may be more involved and may require higher levels of skill than those for the peripheral capital goods. Still, lack of reliability of peripheral capital goods is usually seen by potential customers as a serious danger and a pitfall which should be avoided. For this reason, unless a reputable local manufacturer or manufacturers of peripheral capital goods exist, and if the expertise of selecting such peripheral capital goods and integrating it into a well functioning system is missing, a foreign manufacturer can still be preferred.

3.3 The structure of production of equipment for the food processing industry

The food processing industries constitute a group of very diverse activities. Some of these have some characteristics in common that make it possible to distinguish them from other industries. These main characteristics have to do with the seasonal nature of the agricultural production and food processing, the need to observe hygienic conditions, the handling of perishable products and the great diversity of products and required machines.

The case of the grain milling and the oilseeds processing industry is different. Grains like wheat, maize, rice and others, and oilseeds like soy, peanuts, rape, sunflower, safflower etc. are not classified as perishables. At the same time that adverse temperature and humidity conditions can damage eating quality, the baking quality of grains and oilseeds quality both as sources of oil and of meal could be affected. Since they can be stored, their processing is not carried out as a seasonal operation. Since processing of grains and oilseeds does not involve so many wet stages, maintenance of hygienic conditions is simple.

Out of 50 engineering sectors in six major OECD countries,[27/] machinery for the food processing industry represented only 0.5 per cent of the total output. It is more important in France, the Federal Republic of Germany, the United Kingdom, Italy and the United States. As a whole, the manufacture of capital goods for the food processing industry is rather small in comparison with other sectors. In the EEC, the Federal Republic of Germany is the leading producer of capital goods for the food processing industry.

Three countries, the Federal Republic of Germany, the United States and Japan, account for between 70 and 80 per cent of the total output by value in the OECD countries of capital goods for the food industry. This indicates a high level of concentration of capital goods manufacturing industries in a few

---

27/ Federal Republic of Germany, France, Sweden, Canada, United States, Japan.

countries. These are highly developed countries with a strong domestic market of their own. Despite this fact, there is an ever growing interest and dependency on the large world markets, many of which are located in developing countries.

3.4 Know-how, engineering and services

Reputable and established manufacturers of capital goods for the food industry usually consider their accumulated know-how as their most valuable asset and will protect it by all legal means. This know-how covers the design, selection of construction materials, manufacture, quality control procedures, pricing and marketing. In some cases, the application of the equipment to processing or simply what this equipment can do or produce represents a considerable amount of accumulated know-how which is much deeper than just straightforward operational instructions. Such accumulation of know-how in most cases represents years of continued professional activities in the form of constant efforts to upgrade the quality of the finished products through improved manufacturing processes.

A continuous study of the competition, what it produces and how, is an important element in the activities of a manufacturer of capital goods. Although it seems that the complexity of these issues is lower for manufacturers of peripheral capital goods than for manufacturers of core capital goods, this is not always the case. Although in many cases peripheral capital goods are thus simpler and less expensive to build, the need for their efficient functioning with different types of systems and different types of raw materials, makes their detailed design and precise construction a demanding task. Because of their relatively lower price when compared to that of core capital goods, a peripheral capital goods manufacturing industry requires a wide range of development activities and investment programmes in order to generate a wide enough economic base for its existence.

Existence of engineering capabilities within a country may influence the development of both the core and peripheral capital goods manufacturing industry. Obviously there is a need for engineering skills to be available to the capital goods manufacturing industry. Availability of such engineers is critical for the design, production, control of manufacturing and assembly operation, sales and service. Without such engineers, the setting up of a capital goods manufacturing industry will be slow, risky, probably unsatisfactory and it probably could not compete with foreign manufacturers. Local engineering capabilities are required if a process is to be initiated which will eventually lead to successful competition with engineering services that can be imported.

Importation of engineering services from abroad results many times in importation from abroad of more capital goods than necessary. Even though some peripheral capital goods are available from a national or sub-regional source or sources, only active local engineering activities could identify them and fit them into the required process.

Availability of engineers is critical to continued industrial activities. In this respect several types of activities are to be considered beyond local manufacture of core or peripheral capital goods: Professional assistance in installation of and in supervision of the installation of nationally produced capital goods is required and must be available. Difficulties in obtaining such services for nationally produced capital goods will have a negative effect on purchases of locally produced capital goods. With local representatives of foreign manufacturers, usually well staffed and organized, such trained persons may make a difference between the success of a local capital goods manufacturing industry and its failure.

Equally important are questions of warranty, guarantees, availability of service personnel, spare parts and the cost of these goods and services.

Throughout the capital goods manufacturing industry there is a need for staff training at all levels. Activities that formerly may have represented a low level of knowledge (for example, maintenance operations) now require training at intermediate level in order to give reliable technical assistance to customers. This widespread advance in technology increases the importance of training of workers such as technical supervisors and technicians. At the same time, the use of processing machinery of high value and complexity (metering devices, weighers, closing machines, etc.), and the complexity of know-how in fitting together of sub-assemblies and final assembly, specifications, tolerances and durability make it necessary to raise the level of knowledge and experience of direct production workers at all levels.

Sales personnel, customer technical assistance and repair and maintenance servicemen also play a key role in marketing and their training is of vital importance.

It is necessary to have in the country and in the industry adequate and diversified educational activities directed especially towards providing specialized operators, both for the processing industry and for the capital goods manufacturing industry. Local training in all aspects mentioned earlier are essential for the establishment of an industry producing capital goods, both core and peripheral.

For the production of machinery involving complex technology, diversification of engineering services are required. The qualifications of the technical staff should include production planning and control, standard of maintenance of process machinery and quality control. It may be necessary to have personnel with intermediate and higher education or equivalent in the fields of computer technology, planning methods, statistics and statistical quality control.

3.5 Manufacturing capabilities

In almost all of the developing countries there are at least some capital goods manufacturing capabilities. This capability can be utilized for the production of capital goods for the food industry in general and that of the grain milling and the oilseeds processing industries. If the local metal industry is limited in capacity, demand from the different sub-sectors of the food industry could help in promoting an increase in the size of the capital goods industry. Different measures may still be required for the capital goods manufacturing industry to capitalize on existing and growing demands for its services. Yet a gradual increase in size of this industry could be foreseen, if there is growth in the food industry and other conditions are also met.

For a number of reasons, one of which is the striving for a competitive edge over competitors, many manufacturers of capital goods in industrialized countries seek to locate, participate in or establish a manufacturing base in developing countries. In some cases this takes the form of an establishment of a wholly or a partially owned subsidiary. Being profit motivated, these subsidiaries will establish as wide or narrow a manufacturing base in the developing country as is required in order to meet their estimated potential sales goals.

Such foreign owned subsidiaries are sometimes controlled from abroad and their main profit motivation could be that of attaining maximum profit levels for the parent company and not necessarily a maximum level of profit for the national subsidiary. Nonetheless, these subsidiaries could make a most significant contribution to the establishment of a national capital goods manufacturing industry in a developing country. Such contribution can be envisaged in several ways. It could create a demand for goods and services, providing employment for local people and purchasing of locally produced supplies, services and utilities. It could provide for training of personnel at all levels locally or outside the country as may be required, including such in-house training of local nationals that might not be available otherwise. It could make know-how available to the national subsidiary, including manufacturing drawings which are not otherwise available. It could also open doors for visits of industries in the developed countries where such core or peripheral capital goods are used. Through such visits and other activities the subsidiaries can help promote the establishment of the processing and applications industry in the developing countries.

Foreign suppliers of capital goods could also arrange for local supply of some capital goods by contracting out to existing national suppliers rather than arrange for local construction of capital goods through the establishment of a subsidiary in the country where demand exists. Such an approach, although beneficial to the local industry, is not quite the same as that of an establishment of a subsidiary.

Manufacturing operations in countries of different groupings can be envisaged accordingly. For example:

<u>Level 1</u>	
Brazil, India	Joint ventures, acquisition of licenses.
<u>Level 2</u>	
Colombia	Joint ventures, licensing, transfer of know-how training.
<u>Level 3</u>	
Nigeria	Transfer of know-how, training supervision.
<u>Level 4</u>	
Central African Republic	Only or mostly only import from abroad, together with some local technical limited skills.

A gradual approach for development of a capital goods manufacturing industry can be adopted in the case of levels 3 and 4 countries.

The objective of the first stage could be that of the development of a local capability for maintenance and repair and for construction of simple components. The technology involved should be simple and should be adaptable for small to medium scale installations and companies. There is a need to stimulate local capabilities of entrepreneurs and artisans in sectors such as mechanical and electrical repairs and maintenance, foundry, sheet and plate forming and welding.

A programme needs to be initiated where all capabilities of all local resources are listed and analyzed. This should include all existing operations related to local machine or parts building activities and to all food processing operations requiring or projected to require these services, present and future.

The objective of a second stage could be that of a creation of industrial infrastructure which is required for the establishment of a capital goods manufacturing industry. Once local technology has been upgraded and a basis exists for the supply of goods and services required for maintenance including simple parts, both wear and spare, a second stage can be considered, viz. that of peripheral non complex capital goods. Training and investment in mechanical and electromechanical equipment will be required. When this is achieved, level 4 and level 3 countries could reach a position similar to that of level 2 countries.

Using license or joint-venture will lead to an improved construction capacity for specific machines or specialized peripheral capital goods. This in turn results in a potential capability of manufacturing peripheral non complex machines and spares, and having the infrastructure and personnel required for an even more advanced stage.

3.6 Promotional activities

National governments and international organizations can influence the establishment and the development of a capital goods manufacturing industry. This can be done in various ways.

Promotion of agricultural production and policies resulting in increased food consumption in general and that of milled grained products or vegetable oils in particular, will require additional production capacity of these products. This creates a need to enlarge this processing industry which leads to a demand for the supply of capital goods involved directly or indirectly in the processing of cereal grains and seeds.

Planning of educational programmes at different levels for the training of professionals and support of schools of engineering, will make qualified local engineers available. Similarly, the establishment of vocational schools where training of technicians, machine operators, etc. takes place, will result in the availability of trained workers at all levels without which the capital goods manufacturing industry cannot operate or grow.

4. MAIN FINDINGS AND RECOMMENDATIONS

4.1 General

This study identifies the peripheral capital goods that the grain milling and oilseeds processing lines have in common and those that have a potential for local production in developing countries. This chapter draws on the findings reviewed in chapters 2 and 3. It also interprets and discusses the characteristics of capital goods in the two food industries which are the subject of this study.

4.2 Type of market

The capital goods manufacturing industry in the field of both core and peripheral goods required by the food processing in general and the vegetable oil and grain milling industries in particular, is dominated by a relatively small number of equipment manufacturers. These companies are by and large from the United States, the United Kingdom, the Federal Republic of Germany, Switzerland, Italy, France, the Netherlands and other developed countries.

A number of these companies operate in some of the developing countries together with local groups through different partnership or ownership agreements. Other arrangements, whether temporary or of a longer duration and not on a project basis, involve transfer of know-how in various ways. Some of these companies restrict their activities in the developing countries to that of a foreign supplier with no local manufacturing related activities. In most cases this situation is determined by the size of the potential market in the country, level of technical capabilities, policies, both of the national government and the company itself, and the activities of the competition.

The most important single factor affecting the development of the capital goods industry in the developing countries, both core and peripheral products here analyzed, is that of market size. Knowledge of market development and projections provide a base for the planning of demand in both core and peripheral goods in the future. If the national market is big, specialization in production of vegetable oil processing or grain milling lines are possible. If the market size is not sufficient for such specialization, then possibly specialization in manufacturing of one or more types of equipment, required for more than one type of process is needed. In this report, chapter 2 gives a list of capital goods required by the oilseeds processing and grain milling industries. Projections for the development of these two industries in a particular developing country could provide a base for the establishment of a core or a peripheral capital goods manufacturing industry there.

Still, demand may not be big enough to provide such a base. The incorporation of developments in other sectors of the food industry and their requirements in such a market evaluation may change the picture. Adding the demand by other branches of the food industry for conveyors, aspirators, bins, wastes or other peripheral capital goods to the demand of the oilseeds processing and grain milling industries, could provide a base for future activities in the manufacturing of capital goods.

If such a basis does not exist, then future needs for capital goods for growing processing industries will have to be met from abroad. Such demand may be met by deliveries from other developing nations where an existing larger demand does provide a base for setting up a local capital goods industry. Deliveries from capital goods manufacturing industries established in developing countries to customers in other developing countries may require prior consent of the owner of the know-how. Usually marketing rights and privileges are worked out between the foreign partner who owns the know-how and the local subsidiary.

Delivery of capital goods from a manufacturer in a developing country to an end user in another developing country may broaden the base for the manufacturer and increase its profitability. This could certainly be considered as a desirable development.

4.3 Manufacturing capabilities

4.3.1 Physical plant

The physical characteristics of a plant are related to a detailed analysis of the kind and type of machinery and tools required for the manufacture of the required peripheral capital goods. Examples of capital goods for production in the developing countries are also given for the oilseeds processing and grain milling industries in section 2.8.

The purpose of the analysis is to determine if there is a demand to add to the existing or not yet available manufacturing systems in the country and whether their absence or shortage creates a bottleneck in the local manufacturing capabilities.

4.3.2 Labour force

Part and parcel of national manufacturing capabilities is the availability of workers at all levels to the capital goods manufacturing industry. In this respect the capital goods manufacturing industry for the oilseeds and grains sub-sectors and even that of the whole food sector can be viewed as part of the overall national capital goods manufacturing programme.

In a further step the labour force needs to be evaluated. This evaluation can be broken down into different groups according to professional levels and types. The highest group consists of engineers (mechanical, electrical, chemical), economists and managers/administrators. The capability of the national higher educational system to produce such professionals needs to be determined in view of present and future needs of the capital goods manufacturing industry. The second level consists of senior technicians, capable of filling positions of production managers, shift managers, supervisors, quality control inspectors, draftsmen etc.

The third scale consists of graduates of vocational schools. These schools produce workers with sufficient training to operate advanced technology machine tools and highly qualified welders.

4.3.3 Know-how

Existing or future manufacturers of capital goods can only extend their production programme to the limits of the know-how which they possess. It is necessary to determine as part of the manufacturing capabilities what know-how is required at the different stages of development of the capital goods manufacturing industry and to identify possible sources for such know-how.

4.4 Policies

Whether setting up a peripheral capital goods manufacturing industry for the oilseeds processing, the grain milling industry, or both, or whether setting up both a core and peripheral capital goods industry for a wider industrial sector, the major benefits to the national economy through such activities can be summarized as follows:

(a) It reduces the foreign exchange component of the investment in the project.

(b) It generates employment and income in the local machine building industry.

(c) It starts or adds force to an on-going process of economical development which could bring about an overall improvement in employment, education, income etc.

Working out the required policies for the promotion of a local capital goods industry, these policies should relate to a number of different fields.

4.4.1 Promotion of nutrition, agriculture, food processing

A policy to promote adequate nutrition, increased agricultural production and increased food processing is the key to the creation of a demand for capital goods in the food processing industry.

4.4.2 Assistance to local industry

Based on the knowledge of what is required by way of a capital goods manufacturing industry for the development of the local oilseed and grain milling industries, and by knowing what is available, the government could formulate policies to assist the local capital goods manufacturing industries.

(a) Policies in education and training

Plans for educational activities should be made and should be followed by actions which would result in the training of professionals at all required levels. These activities may include promotion and support of training of individuals in selected fields abroad, training of teachers and instructors, financial assistance to students and learners of vocations.

(b) Guidance and direction

The role of governments in offering guidance and direction could be of vital importance for the development of the capital goods manufacturing industry. An example would be to offer investment support schemes that will encourage the industry to follow government planning objectives. These support schemes could be in the form of grants or loans made towards purchase of land, buildings, manufacturing tools and machines. They can also be given towards expenses in training, organization and working capital to see the capital goods manufacturing through the first few lean years.

(c) Financing and protection

Having sufficient financial help from the banking system can be of extreme importance to the recently established capital goods industry. Helping this industry secure its share of the business growth in the oilseeds processing and grain milling industries is an important task. This can be achieved by encouraging the local industry to purchase products produced locally. Such encouragement could be in the form of duties and levies on importation, exchange rate policy, grants and easy loans towards purchase of locally manufactured capital goods an in extreme situations protection of similar national industries.

4.5 Main obstacles to entry into capital goods manufacturing for the oilseeds processing and grain milling industries

The developing countries could be divided into four categories, as proposed in section 3.4. In countries like Brazil or India all capital goods required for the two sub-sectors (oilseeds processing and grain milling) can be produced nationally, much of it in co-operation with foreign companies. At the bottom of the line in developing countries there are manufacturers with hardly any technical capability, and the chances for a big and stimulating demand for capital goods are rather slim.

Between these extremes, one could find countries like Colombia in which the capital goods manufacturing industry is not quite as established and all encompassing as that of Brazil or India, but is certainly in existence and very active.

4.6 Suggested follow-up actions

The peripheral capital goods that the grain milling and the oilseeds processing lines have in common, and those that have a potential for local production in developing countries are:

Peripheral capital goods	Core capital goods
Pumps (some	Grain dryers (some)
Electrical motors (some)	Batch extractors
Control pannels (some)	
Tanks, settling tanks	
Magnet cleaners	
Air compressors	
Aspirators	
Conveyors	
Cyclones	
Hoppers	
Liquid storage tanks	
Bagging equipment	
Bins	
Steam boilers	

Equipment types common to both sub-sectors.

Developing countries are not equal in their level of development. In some, capital goods equal or higher in complexity than those listed above can be manufactured. In others, capabilities in production of capital goods like those listed above may exist but in order to take advantage of what the capital goods manufacturing industry has to offer, a certain level of engineering competence has to be achieved first. In other developing countries only some of the above-mentioned capital goods can be secured locally and yet in other developing countries none can be produced locally.

For this reason the following follow-up actions are suggested:

(a) To study the projected dynamics of the development of the vegetable oils and fat manufacturing industry and the grain milling industry on a national basis in each of the developing countries in order to estimate future volume of business in manuacturing of peripheral or core capital goods. The study should include the demand for capital goods in the oilseeds and grains processing sectors, cost of equipment, analysis of cost of manufacturing and marketing of capital goods producible in the country. It should further provide the information required in order to make a decision whether the potential volume of business will indeed provide an economical basis for operation. If such basis does not seem to exist, an inclusion of capital goods requirements for other industrial sectors in the country, and particularly the food industry, to potentially provide extra demand and thus provide a proper economic base of operation should be investigated. Such a report provides a basis for drawing up a strategy for the development of the capital goods (core and peripheral) of the vegetable oils and fat manufacturing industry in the developing countries.

(b) To draw up a strategy at national level to establish the factors both quantitatively and qualitatively which together determine the local capabilities in manufacturing of capital goods for the oilseeds processing, the grain milling and possibly other industries or sub-sectors of the food industry, based on marketing opportunities established earlier in section 4.2.

(c) Based on (a) and (b) above, local governments should be assisted in formulating policies to create opportunities and incentives for private and public enterprises to become active in capital goods manufacturing for the oilseeds processing and the grain milling sub-sectors.

(d) In order to meet future demand and to facilitate the development of the capital goods manufacturing industry there is a need to establish national policies and plans of execution in the field of technical education and training. The possible development of a local capital goods manufacturing industry and its growth dynamics should determine what types of educational and training programmes will be required, when and at what scale.

REFERENCES

1. World Conference on Oil Seed and Vegetable Oil Processing Technology, 1-5 March 1976, Amsterdam, Reprinted, June 1976, The Journal of the American Oil Chemists' Society.

   1.a Gustafson, E.H., Loading, Unloading, Storage, Drying and Cleaning of Vegetable Oil-Bearing Materials. Pp.248-250.
   1.b Galloway, J.P., Cleaning, Cracking, Dehulling Decorticutin and Flaking of Oil-Bearing Materials. Pp.271-274.
   1.c Bernandini, E., Batch and Continuous Solvent Extraction. Pp.275-278.
   1.d Milligan, E.D., Survey of Current Solvent Extraction Equipment. Pp 286-290.
   1.e Burkhalter, J.P., Crude Oil Handling and Storage. Pp.332-333.
   1.f Duff, A.J., Automation in Vegetable Oil Refineries. Pp.370-381.
   1.g Barrman, C., Small Scale Processing of Vegetable Oils. P.338.
   1.h Schumacher, H., Ultimate Energy Possibilities In Conventional Solvent Extraction. Pp.417-419.
   1.i Jurlstowszky, G., Economics of Energy Use in Various Solvent Extraction Processes. Pp.427-429.

2. World Conference on Oil Seed and Edible Oil Processing, October 1982, The Hague. Proceedings, Journal of the American Oil Chemists' Society, February 1983.

   2.a Berger, M.G., Production of Palm Oil from Fruit. Pp.206-211.
   2.b Bredeson, D.K., Mechanical Oil Extrction. Pp.211-214.
   2.c Myers, N.W., Solvent Recovery. Pp.224-226.
   2.d Jokinen, K., Sakko, J., and Stenlund, L., Automation in a Vegetable Oil Extraction Plant. Pp.436-443.
   2.e Gavin, A.M., Energy Conservation in Edible Oil Processing. Pp.420-426.

3. Kock, M., Basis for a Quality Improvement of Soybean Oil by Treatment of the Soya Flakes Prior to Extraction. 36 DGF Vortragstagung, Kiel, September 1980.

4. Cereals Production. J. Mackey, in Cereals, A Renewable Resource, Edt. Pomeranz, Y., and Munk, L. American Association of Cereal Chemists' Incorporation 1981.

5. Wheat, Chemistry and Technology, Edt., Pomeranz, Y., American Association of Cereal Chemists' Incorporation 1978.

6. Technical Literature of Buhler Brothers, Uzwil, Switzerland.

7. Rice Parboiling, by Gariboldi, F., FAO Agricultural Development Paper No. 97, FAO, Rome 1974.

8. Study on Selection of Technological Processes in Sub-sectors of Food Processing Industry, by Nuti, G.A., UNIDO Consultant, 1982.

9. Corn, Culture, Processing, Products, Inglett, G.E., Edt. Avi, Westport, Conn., 1970.

10. Shukla, P.T., Industrial Uses of Dry-Milled Corn Products, in Cereals, A Renewable Source, Editors, Pomeranz, Y., and Munk, L., Publishers, The American Association of Cereal Chemists' Incorporation 1981, p.489.

11. Technical Literature of Ocrim S.p.a., Cremona, Italy.

12. Corn Dry Milling Industry, Brekke, O.L., in Corn: Culture, Processing, Production, Inglett, G.E., Editor Avi, Westport, Conn., 1970, pp. 262-292.

13. United States Crushing Trends, American Journal of, Oil Chemists' Society, pp.62, 1985.

14. Bolling, H., Milling of Cereals for Total Utilizaton Resource, Editor, in Cereals, A Renewable Source, Pomeranz, Y., and Munk, L., American Associate of Cereal Chemists Incorporation, 1981, pp.137-144.

15. UNIDO International Centre for Industrial Studies, Draft World Study of Agro-Industries 1975-2000 and perspectives, UNIDO/IS.477.

16. UNIDO, The vegetable oils and fats industry in developing countries: outlook.

17. The Engineering and Electrical Industries inthe OECD Member Countries. OECD publication, Paris, 1977.

18. The Engineering Industries in OECD Member Countries New Basic Statistics. 1963-1970 (OECD).

19. Instituto de Investigaciones Technologicas, Bogotá, Colombia. Plant for Production of Precooked Maize, 1980.

SOMMAIRE

Cette étude traite la question des besoins en biens d'investissement de l'industrie d'alimentation et en particulier ceux des sous-secteurs de la minoterie et du traitement des grains oléagineux. L'étude donne une analyse de l'opération de ces deux sous-secteurs et décrit les biens d'investissement utilisés par eux. Un des buts immédiats de l'étude est l'identification de ceux parmi les biens d'investissement considérés comme périphériques, commun aux deux sous-secteurs, notamment la minoterie et le traitement des oléagineux qui pourraient être produit dans les pays en développement.

Après l'introduction, chapitre 2 passe en revue les principaux procédés de production pour les oléagineux, huiles végétales et pour la minoterie. Ce chapitre traite aussi la technologies de l'extraction et du traitement de l'huile végétale et donne une liste des biens d'investissement les plus importants utilisés dans les deux sous-secteurs mentionnés, séparément pour les biens appartenant au moyau du procédé et pour ceux considérés périphériques.

Chapitre 3 donne une aperçue des problèmes et thèmes fondementaux dans la fabrication des biens d'investissement pour l'industrie d'alimentation en générale et pour la minoterie et le traitement des oléagineux en particulier. Le fait et la manière de la domination de ce marché par les sociétés internationales peux nombreuses qui fabriquent des biens d'investissement pour l'industrie d'alimentation et spécialement pour ces deux sous-secteurs sont aussi traités. Enfin, le chapitre 4 est consacré aux conclusions et recommendations principales. Au fond, les recommendations se référent à la détermination de la demande des biens d'investissement pour les sous-secteurs étudiés et ensuite à l'étude et à l'établissement des moyens qui pourraient améliorer les capabilitées locales dans les pays en dévéloppement dans ce secteur, et finalement à la question comment entamer un programme directeur pour les gouvernements nationaux.

EXTRACTO

Este estudio se refiere a los bienes de capital de la industria de alimentos y partícularmente a aquellos requeridos por los subsectores de la industria molinera y la de procesamiento de semillas deáginosas. El estudio analiza estos dos subsectores de acuerdo a las unidades de operación y a los bienes de capital centrales y periféricos que ellos utilizan. Un objetivo inmediato de este estudio es por lo tanto identificar los bienes de capital periféricos que la industria molinera y la industria de procesamiento de semillas deáginosas tienen en común y los cuales representan un potencial de producción en países en desarollo.

Siguiendo la introducción, el capítulo 2 hace una revisión de los principales procesos de producción de las industrias de procesamiento de semillas deáginosas y de la industria molinera, asi como de la tecnología requerida. Este capítulo presenta tambien un desglose de los bienes de capital centrales y periféricos más importantes requeridos en los subsectores bajo análisis.

El capítulo 3 revisa los problemas básicos y temas de discusión alrededor de los bienes de capital de la industria de alimentos en general y de los subsectores de la industria de procesamiento de semillas deáginosas y de la industria molinera en particular. Aquí, se analiza iqualmente la importancia de los líderes mundiales fabricantes y su papel dominante en la producción de los equipos centrales. Finalmente el capítulo 4 contiene las principlales conclusiones y recomendaciones. Fundamentalmente, las recomendaciones se refieren a la necesidad de proyectar la demanda de los bienes capital requeridos por los subsectores y a determinar los pasos a seguir para mejorar las capacidades locales de produccion de la industria de bienes capital en los países en desarrollo, asi como la de iniciar un programa guía a ser seguido por las autoridades locales.

For the guidance of our publications programme in order to assist in our publication activities, we would appreciate your completing the questionnaire below and returning it to UNIDO, Division for Industrial Studies, D-2119, P.O. Box 300, A-1400 Vienna, Austria

---

QUESTIONNAIRE

Capital goods in oilseeds processing and grain milling industries

	(please check appropriate box) yes	no
(1) Were the data contained in the study useful?	/_/	/_/
(2) Was the analysis sound?	/_/	/_/
(3) Was the information provided new?	/_/	/_/
(4) Did you agree with the conclusion?	/_/	/_/
(5) Did you find the recommendations sound?	/_/	/_/
(6) Were the format and style easy to read?	/_/	/_/
(7) Do you wish to be put on our documents mailing list?	/_/	/_/
	If yes, please specify subjects of interest	
(8) Do you wish to receive the latest list of documents prepared by the Division for Industrial Studies?	/_/	/_/

(9) Any other comments?

Name:
(in capitals) ....

Institution:
(please give full address ....

Date: ....