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MONOGRAPHS ON APPROPRIATE INDUSTRIAL TECHNOLOGY

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR OILS AND FATS

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna

Monographs on Appropriate Industrial Technology
No. 9

APPROPRIATE INDUSTRIAL TECHNOLOGY FOR OILS AND FATS

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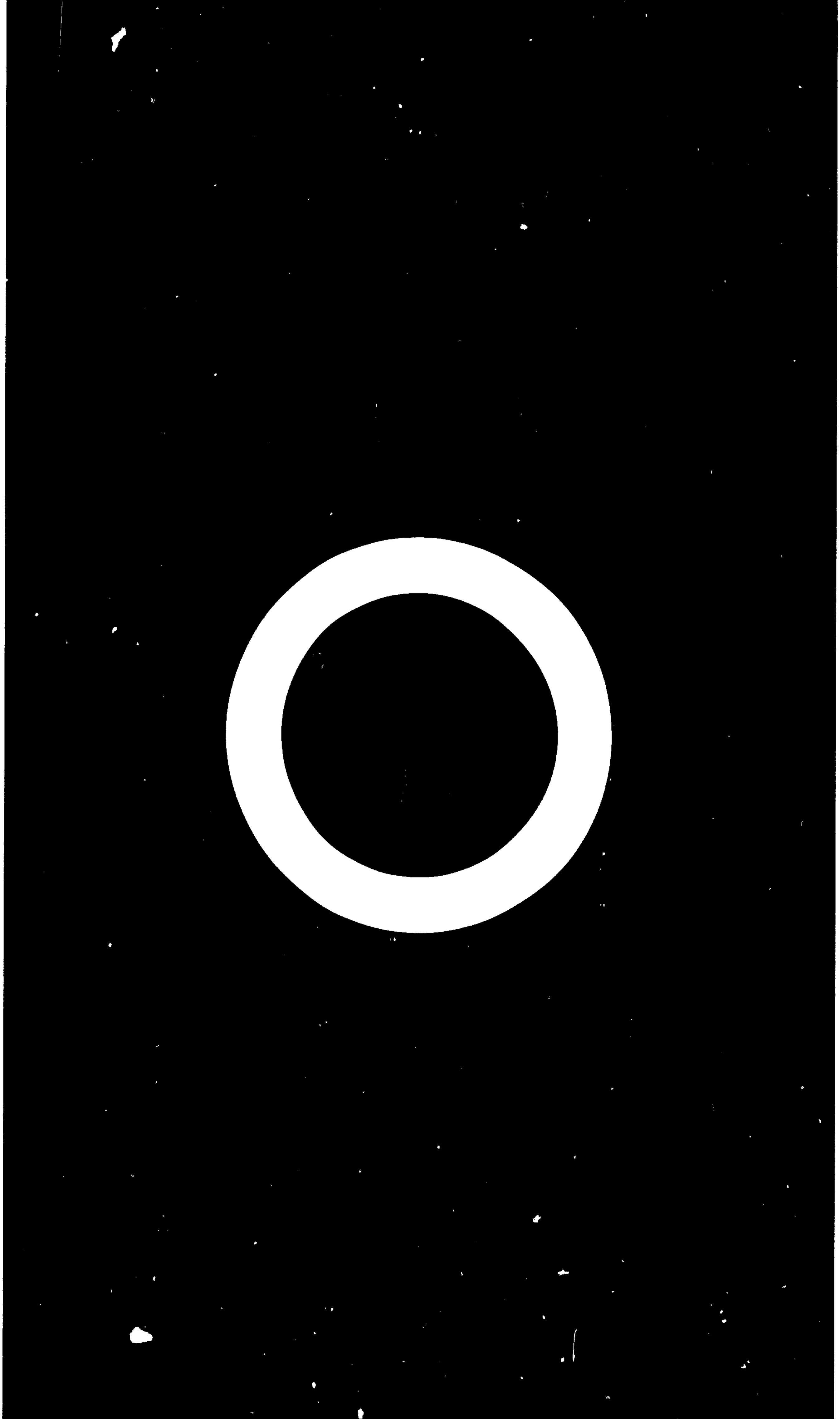

EXPLANATORY NOTES

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

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

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

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

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

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

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

The word billion means 1,000 million.

The word lakh means 100,000.

The following notes apply to tables:

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

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

A blank indicates that the item is not applicable.

Totals may not add precisely because of rounding.

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

Organizations

GCMB Ghana Cocoa Marketing Board

Technical abbreviations and symbols

FFA free fatty acid

R and D research and development

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

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

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

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Foreword

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

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

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

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

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

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

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

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

Abd-El Rahman Khane
Executive Director

Preface

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

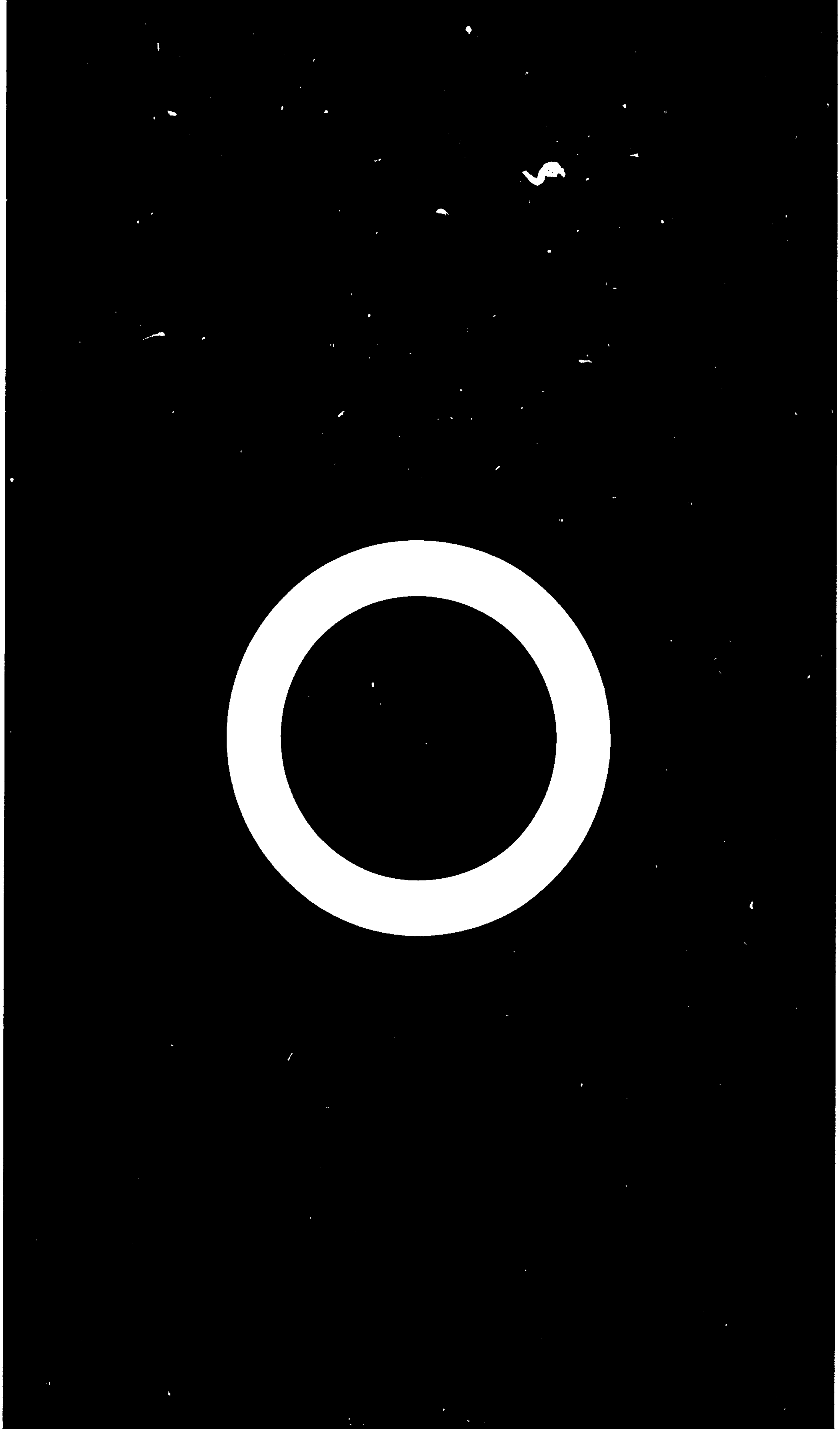
In response to a recommendation of the ministerial-level meeting, UNIDO, with the help of a generous contribution by the Swedish International Development Authority, is publishing this series of monographs based mainly on documents prepared for the technical/official-level meeting. There is a monograph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

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

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

PART ONE

Issues and considerations



Note by the secretariat of UNIDO

INTRODUCTION

In most developing countries the oils and fats industry is an important agro-industrial activity that could be the basis for further industrialization; the primary processing of the oil-seeds or kernels into crude oil is undertaken in almost all the developing countries. Secondary processing is less developed, although facilities for it are being built to varying extents. Soap-making is prevalent, and its technological base is simple. The making of margarine and washing powder has made limited progress because of the limited internal market for the products.

The annual *per capita* consumption of oils and fats for food has been reported to be 5.1 kg in Africa, 4.4 kg in Asia, 8 kg in Latin America and 7.4 kg in the Middle East, as against an average of 20 kg in the developed countries.

The palm-oil industry in the Ivory Coast and Malaysia serves the social purpose of industrialization by providing employment. The processing of oil-seeds and their by-products also provides extensive employment opportunities. Cotton seed differs from other oil-seeds as regards its processing and the utilization of its by-products. Nevertheless, its processing serves similar economic and social purposes.

There are two primary technologies for extracting oils: mechanical expression with screw-presses and solvent extraction.

According to a United Nations Industrial Development Organization (UNIDO) study,[1] the share in the processing technologies of the developing countries as a whole, on the village scale, is 8–10 per cent; in small-scale expellers, 45–55 per cent; in the medium to large-scale expellers, 25–30 per cent; and in solvent extraction 12–18 per cent.

In the oils and fats industry in the developing countries, various more or less sophisticated levels of technology have been applied in varying degrees. Organizational problems such as providing raw material through an adequate transport and distribution system and other supporting facilities require consideration. The oil-seed mechanical processing industry lends itself to decentralized operations without necessarily sacrificing processing efficiency or product quality. The socio-economic benefits could be immense when appropriate technologies are adopted.

Oil-seed processing can contribute significantly to the economies of the developing countries. For instance, nearly one third of the population of the

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[1] "Draft world-wide study of the vegetable oils and fats industry, 1975–2000" (UNIDO/ICIS. 46).

Philippines and an even greater proportion in some Pacific island countries depend on the coconut industry and its by-products. The oil-palm plays an important role in the economies of the Ivory Coast and Malaysia.

Intergovernmental bodies have been established, namely the African Ground-nut Council, the Olive Oil Council and the Asian and Pacific Coconut Community, which promote the development of these industries. Several transnational corporations are engaged in the extraction and refining of vegetable oils and the production of shortening, soap and synthetic detergents in a number of developing countries.

Among the processed products are refined oils used in cooking, margarine, soap, and oil-seed cakes and meals. Oil-seed cakes and meals constitute the most important protein component in the manufacture of compound animal feeds or balanced rations.

For the development of a sound oils and fats industry, the following factors should be taken into account:

(a) Efficient utilization of indigenous oil-bearing raw materials for the production of oils and fats, and the maximum utilization of their by-products;

(b) Fuller utilization of installed capacity for vegetable oil extraction, refining, processing and the like;

(c) Utilization of oil-seed cake and meal as sources of protein and the development of animal-feed industries;

(d) Establishment or strengthening of national technological institutes for the selection, development, application and transfer of technology, and for the provision of extension services and information dissemination, and also the development of design and engineering capabilities to manufacture the equipment and machinery required for the industry.

I. REVIEW OF ALTERNATIVE TECHNOLOGIES

The oils and fats industry presents an interesting range of widely varying plant sizes and production capacities. Investment and entrepreneurial requirements vary from small-scale, simple oil-seed crushing units to integrated complexes such as those in the oil-palm, coconut, cotton-seed and soya-bean processing industries. In general, the simple technologies employed in most developing countries have tended to be wasteful. Considerable improvements could be brought about in oil extraction, refining, margarine production, as well as in the utilization of by-products such as oil-seed cake and meal. The employment potential is quite large and the industry lends itself to increased decentralization. Oil-palm processing should be performed within the cultivation area because of the rapid deterioration of the fresh fruit bunches; however, even other oil-seeds could be processed conveniently nearer the source of production of the raw material. However, when industry is export-oriented or is required to meet a large demand for a concentrated urban population, the establishment of integrated complexes because of the availability of markets or export facilities would seem to be justified.

In the case of edible oils, marketing and distribution also present an interesting picture. In most developing countries, patterns of consumption vary, and packaging, transport and distribution techniques vary as a result. A few developing countries, such as Brazil (soya-bean oil), Malaysia (palm oil) and the Philippines (coconut oil), are exporters. Most other countries are either self-sufficient or are importers of oils and fats. Where supply is less than demand, prices are invariably higher than the world market prices. Government intervention in importing the needed oils and fats helps to meet the demand to some extent, but consumer prices tend to remain high. The foreign-exchange constraint is an important consideration in the importation of vegetable oils and fats.

As a part of the preparations for the First Consultation Meeting on the Vegetable Oils and Fats Industry in December 1977, UNIDO commissioned a world-wide study on the vegetable oils and fats industry.[1] The study examined the patterns of production, trade and prices of oil-seeds, *vanaspati* (hydrogenated vegetable oils) and soap-making. Particular reference was made to the underutilization of capacity. The main variables that influence the development of the industry were indicated. The future trends of growth and expansion of the industry were also postulated, and the problems and constraints that tend to limit the efficiency and expansion of the industry were discussed. The point was made that policies and strategies must be developed and implemented to overcome the constraints on production.

Village processing methods have limitations. Hand-operated processing methods are inefficient and waste resources, and by-products are not used to best advantage. These processes could and should be upgraded. In the context of examining appropriate technology, that is, technology that would bring maximum socio-economic benefits to the majority of the population, it would seem advisable to concentrate on mechanized processes and search for alternatives to meet the objectives already outlined. It is considered necessary to improve the ghani technique of oil extraction. The oil-extraction efficiency of this method is admittedly poor when processing oil-seeds such as ground-nuts and sesame. In this type of processing, the residual oil content of the oil cake (18 per cent or more) is wasted. So high a content is not required even if the cake is used as a cattle feed. Therefore, wherever feasible, the technology should be upgraded by the substitution of mechanical screw presses, which ensure a higher rate of oil recovery. Along with such technological improvements, due attention should be paid to the transport, storage and handling of the oil-bearing raw materials. Ground-nuts, for instance, if they are not properly dried after harvest and if breakages occur in the seed, are susceptible to bacterial attack: aflatoxin develops, reducing the value of the oil-cake or oil-meal. Under certain circumstances it might be possible to collect the available oil from small oil-milling units and process it to yield refined cooking oils, hydrogenated oils (vanaspati) or shortenings.

In commercial processing, attention should be paid to the handling and storage of oil-seeds to avoid damage and to minimize the natural deterioration that leads to increases in free fatty acid (FFA) content, the development of objectionable odours, flavours and colours in the extracted oil and lowered quality of the residual oil-cake or meal. Successful storage of oil-seeds avoids moisture levels at which the proliferation of fungi and bacteria and the activity of enzymes lead to rapid deterioration.

Oil-bearing materials with special requirements

Oil extraction and refining techniques are explained in the UNIDO study.[1] It would be useful, however, to examine here the processing of some specific oil-seeds or oil-bearing materials that call for special pre-treatment and processing techniques. The method of oil-seed processing either by mechanical expression or by solvent extraction is much the same with most raw materials such as ground-nuts and sesame, rape and mustard seeds. However, there are some oil-seeds or oil-bearing materials in which there are variations of processing technology. It is for this reason, that in the following paragraphs the processing technologies of some selected ones, namely cotton seed, coconut, oil-palm, rice bran and soya beans, are discussed.

Cotton seed

In cotton-seed processing, the oil is extracted to some extent by traditional techniques without delinting or decorticating the seed, which results in poor yields of both oil and cake. An efficient cotton-seed-crushing unit would provide suitable storage facilities for the seed and, at the first stage, clean it to remove stalks, leaves and so on and then subject it to delinting, which would produce first- and second-cut linters with specific uses as raw materials for specialized types of paper-making and cellulose-acetate production. The seed is then decorticated, separating the hulls from the meats. The meats are cooked and subjected to either mechanical expression, solvent extraction or both. Under these circumstances the yield of oil is higher and its quality better. The hulls have an economic value as roughage in animal feeds. The cotton-seed cake or meal is of a better quality and is an important raw material for the manufacture of compound animal feeds.

If the industry is decentralized, there should be no compromise as to the efficiency of processing the cotton seed and its by-products. Perhaps the adaptation of the technology to permit processing in the small- and medium-scale sectors should be considered.

Coconut

Another interesting example is the processing of coconut products. The current methods for the primary processing of coconut into copra and the further stages of conversion into oil and cake, refining the oil and so on, as well as the utilization of by-products of oil-cake or oil-meal, fibre (coir), shell etc., could stand considerable technological improvement. Improvements in the production of copra would prevent its deterioration by fungal attack and improve the quality and quantity of both oil and cake.

Coconut oil has unique physical and chemical properties and a number of nutritive and industrial uses. It is an excellent raw material for making margarine and special detergents.

The coir industry is an ideal rural one with immense employment potential. The shell has important uses, e.g. the production of charcoal and activated carbon. In the decentralization of the coconut products' processing industries, efficiency must be maintained at all levels.

Oil-palm

Palm-oil processing techniques vary widely in the developing countries. The Ivory Coast and Malaysia have emerged as large-scale producers and exporters of palm oil. The rationale for establishing the palm-oil industry there is that the trees grow only within 15° of the equator. In some countries the industry is being promoted to replace unproductive or underproductive rubber or coconut plantations. Recent developments in Malaysia and Papua New Guinea have, however, been based on a systematic clearing of the jungle and planting high-yielding varieties of oil-palms. The projects, as envisaged and implemented in Ivory Coast and Malaysia, are integrated agro-industrial complexes. The new projects in the public sector in Malaysia have been serving the purpose of settling landless people, generating employment and providing substantial earnings of foreign exchange by the export of oil and processed products. Recently, a valuable oil is also being extracted from palm kernels. Crude palm oil is gradually being replaced by fractionated and refined products for export. Thus although decentralization cannot be strictly applied in the palm-oil industry, the integrated operations do serve the socio-economic objectives.

Rice bran

Another oil-bearing raw material with special technical problems is rice bran. It is a by-product of rice milling; brown rice, when polished, yields 7–8 per cent rice bran. Depending on the pre-treatment, yield of bran and its oil content (18–22 per cent) vary. Immediately after the bran has been separated from the rice kernel a lipolytic splitting process rapidly produces FFA thereby causing a high FFA content in the rice-bran oil. While it is technically feasible to stabilize the rice bran to increase its keeping quality, the existing pattern of rice mills, which are small and scattered over the rural areas, presents a problem of collection and transport. Consequently, the development of low-cost, small-capacity rice-bran stabilization units, preferably using rice husks as fuel, is being investigated. Should there be a breakthrough in technology to develop a stabilization unit suitable to small-scale operations in rural areas, substantial amounts of rice-bran oil could be extracted, refined and used as an edible oil in the rice-producing countries.

Soya beans

Any consideration of oil-seed processing would be incomplete without a reference to soya-bean processing. While the oil content of the bean is 18–20 per cent, the yield of 70–75 per cent of the cake or meal makes it a more important product from the protein viewpoint. Additionally, soya-bean protein has a superior amino-acid profile and is thus highly desirable as an ingredient for the production of animal feeds. In eastern Asia, the soya bean has been traditionally used as a source of protein food in fermented products such as bean curd *(tofu)*. These techniques could be further strengthened for fuller utilization of the soya bean as a source of protein.

TECHNOLOGICAL AND OTHER CONSIDERATIONS

Utilization of residual cake or meal needs particular attention. Although in principle its protein could be used to enrich starchy diets, this has not been found to be economic in most developing countries. However, in these countries, in addition to oil-seed cake or meal, rice bran, maize, tapioca and millet are usually available. Therefore, the production of compound animal feeds (balanced rations) could be taken up extensively in the decentralized sector. The animal-feed industry is also the basis for the development of the dairy and meat industries (poultry and pig farming). In view of the low level of technology involved, suitably scaled-down feed mills should be designed and developed for the rural areas where raw materials are available for processing.

Planned production and utilization of oil-seed raw materials for processing

The basic question in planning the utilization of oil-seeds should be the relationship between agriculture and industry, post-harvest operations, infrastructural requirements, appropriate planning and co-operation between planning authorities, departments of agriculture or primary industry and the processing industry. It would seem necessary to establish a suitable co-ordinating mechanism within the Government to ensure that planned objectives are implemented.

Structure of the processing industry

The questions in establishing a processing industry are centralization versus decentralization; village and small-scale industry and the problems that they cause; and the pre-conditions and requirements of a modern large-scale industry, its advantages and disadvantages, and the possible plant locations. In considering decentralization, the main issue would be the extent of decentralization that would not jeopardize the broader objectives of efficient extraction of the oil and economic utilization of the by-products.

Market for oils and oil-cake

Market-oriented production should be stressed with regard to the quantities and quality of the products in demand; domestic consumption habits, such as preferences for a particular oil such as ground-nut, rape-seed or sesame; and the market price structure and its influence on the processing costs and technology. The packaging problem, trade names and brands for edible oils and the importance of local markets for oil-cake and oil-meal are other points for consideration.

Mechanical pressing technologies

The points for consideration in the adoption of mechanical expression technologies are their advantages and disadvantages, energy consumption, spare-part supplies, appropriate processing in view of the production of quality products and the conditions under which pressing plants can be operated efficiently.

Solvent-extraction technology

There are many alternative types and scales of solvent-extraction technology, both batch and continuous, with capacities ranging from 50 to 200 t/d. Their advantages and disadvantages must be considered, and there are the questions of the solvent to be used, the safety and security of the process, losses of the solvent and of alternative appropriate processing operations. The value of the extracted meal compared to that of pressed oil-cake and its use in the food and animals-feed industries must be considered. There are also such questions as the training of staff, plant maintenance and process control.

Technologies for pre-pressing before solvent extraction

The conditions under which there should be pre-pressing, as with such high-oil-content materials as copra (65 per cent) and ground-nuts (45 per cent) should be investigated. Pre-pressing and normal pressing plants should be compared as regards the economics of their operation and their economies of scale, direct solvent extraction after pre-pressing, and the place of pre-pressing in multipurpose processing plants. A related question is that of processing, in centrally located solvent-extraction units, oil-seed cakes collected from scattered pressing plants.

Vegetable-oil refining technology

Among the technological considerations in vegetable-oil refining are its various steps; batch versus continuous operations in bleaching, neutralization and deodorization; the various refining processes; appropriate equipment; losses in refining; soap stock and its utilization; the waste water; bulk storage of the refined oils; bottling and the production of bottles and tins; and the requirements of process control.

Impact of vegetable-oil industrialization on the social and industrial structure and overall industrial development

Among the factors to be considered are the relationship between the vegetable-oil industry and the soap, food and animal-feed industries; the creation of employment as primary and secondary results; the relative advantages of labour-intensive factories and mechanized processing plants; staff training and other educational aspects; and the local manufacture of spare parts and equipment.

Pre-investment considerations and the creation of the pre-conditions for setting up viable vegetable-oil factories

The market-oriented approach to the creation of a viable vegetable-oil industry is the most appropriate. It consists of three steps:

First, the identification of products for which there is a present or probable demand. Second, identification of the raw materials needed. This would include their possible importation or the elaboration and implementation of plans to produce them, and the selection of the most suitable varieties. Third, preparation of a detailed definition of the type of plant required to produce the products in demand in appropriate amounts, of suitable quality and at permissible cost from available raw materials. Some of the considerations at this level are the time factor, the need to establish related industries such as animal feeds or soap, and the creation of additional markets for oil-seed products and the long-term planning requirements in this context.

II. POLICY IMPLICATIONS OF ALTERNATIVE TECHNOLOGIES

As mentioned earlier, the low technological level of village oil expellers could be modernized by the introduction of screw-presses, and factories could be operated efficiently in the decentralized sector. However in export-oriented industries such as oil-palm, coconut and soya-bean processing, the most modern and sophisticated technology must be adopted. Furthermore, the organizational and management structure should be of a high order if it is to withstand competition, not only in terms of price and quality but also in the ability to export to international markets. There is already evidence of the existence of such competence and advanced technology in Brazil for soya-bean products, in the Ivory Coast and Malaysia for palm oil, and in the Philippines for coconut products.

In the selection and adoption of appropriate technologies and processes, regulation by government agencies would be necessary. This could take the form of reservation of capacity for the decentralized sector and the provision of adequate credit and marketing facilities.

Taxation could be used as an incentive for the development of the decentralized sector. Such incentives have been given for the development of cotton-seed and rice-bran processing and solvent-extraction industries in their early stages of development.

Price control of oils and fats could be an effective incentive to the small-scale sector. It would be justifiable because they are essential commodities.

Technological institutions should undertake design and engineering activities to develop prototype equipment suited to small- and medium-scale operations. They should also conduct training programmes, provide extension services and disseminate information.

Government departments, R and D institutes and manufacturers' associations should co-operate in determining alternative technologies for the decentralization of the oils and fats industry.

III. PROGRAMME OF ACTION

Research into the technological aspects of storage and processing of a variety of oil-seeds and their by-products would be necessary. This is particularly true of the palm-oil industry where traditional techniques must be upgraded. In the coconut industry, wet processing of the nuts is already a subject of such research. In the cotton-seed industry, more efficient processing of the seed and utilization of the by-products (linters, hulls and oil-seed cakes or meal) merits consideration. As for rice bran, its stabilization to facilitate the production of rice-bran oil of edible quality has been initiated. Soya-bean processing and its utilization as a source of protein food needs further study and research. Similar research in the technological aspects of other oil-seeds such as rape-seed must be considered. In most developing countries it would be necessary to support R and D activities through the existing national research institutes.

The developed countries and their aid agencies could co-operate in one or more of the following ways:

(a) In some developed countries, extensive R and D is being carried out in support of the development problems of the developing countries. Such activities could be made more specific, both for individual countries and subregions, in the resolution of identified problems;

(b) Developed countries and international agencies could support national R and D engineering activities by providing both technical and financial assistance;

(c) The technical assistance programmes of some of the developed countries, such as in carrying out feasibility studies, improving processing technology and storage practices, setting up laboratories and quality-control systems, may be oriented towards the decentralization of the industry;

(d) International aid agencies might provide capital funds for the development of oils and fats industries that use more appropriate technology;

(e) International co-operation could assist the national institutions in collecting, analysing and disseminating information on alternative technologies and new developments and promote the exchange of experiences relevant to the processing of a variety of oil-bearing materials and their by-products;

(f) Training is yet another important area of co-operation.

Technical co-operation among developing countries would also be valuable, especially in the search for alternative technologies and decentralization of the industry.

Under the UNIDO System of Consultations, the search for alternative technologies and their socio-economic advantages could be examined for future international co-operation.

Co-operation between developed and developing countries with a view to establishing plants for the manufacture of necessary equipment and machinery for the oils and fats industry merits consideration.

Recommendations of the Working Group

The relationship between the oil-seed processing industry and the agricultural oil-seed production sector should be improved by establishing suitable organizational measures to support the production of suitable oil-seed crops in the interest of the farmers on one hand and to facilitate the provisioning of the processing industry with the required quantities and quality of raw materials on the other. Such measures would consist of setting up financing arrangements through the establishment of special institutions that would support the farmers, guaranteeing oil-seed price structures and directing adequate supplies of oil-seed raw materials to the processing industry

The authorities should give preference to supplying the domestic oil-seed processing industry, over exporting oil-seeds. Protection of the processing industry would benefit the country by supplying its domestic market with oils, fats and protein-rich cake.

The Governments of developing countries that wish to develop or establish vegetable-oil industries based on the application of appropriate technology should carefully study and evaluate their particular situations in terms of their development objectives, the optimum utilization of raw materials and the production of marketable products, as well as the economic and social aspects and the technical and engineering requirements.

UNIDO is requested to extend its services to developing countries by transferring the experience of other countries in the adaptation of technologies, so that the most appropriate technology can be selected. In this connection, the UNIDO Industrial and Technological Information Bank (INTIB) should be made an instrument for the exchange of information and views on appropriate technology between all interested countries.

Government authorities should be requested to take the necessary action to establish standards of quality that are valid for the country's entire oils and fats industry, including small and rural production units.

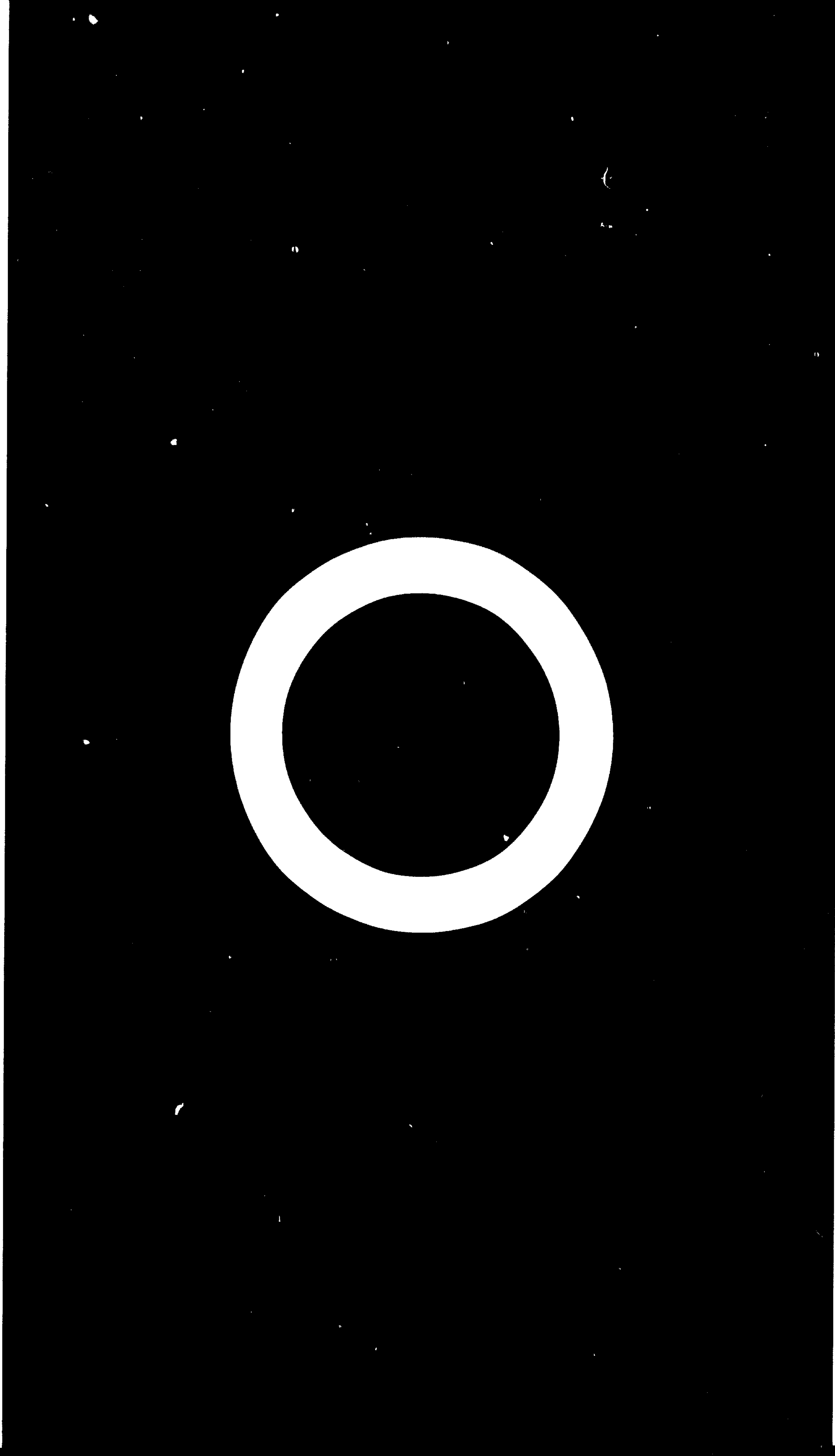
Suitable packaging must be considered part of appropriate vegetable-oil technology. Packaging materials should maintain product quality, be practical in handling, meet hygienic requirements and cause no environmental problems.

When planning for the development of the vegetable-oil industry, the necessary linkages to related industries such as animal feeds, soap, glycerine, pharmaceuticals and cosmetics should be given due consideration.

It is necessary to strengthen and encourage R and D activities in order to develop processing technologies, further improve oil-seed raw materials production and, in particular, exploit non-traditional oil-seeds. Mechanisms should be developed to facilitate the exchange of views and experiences among developing countries and between developing and developed countries.

PART TWO

Selected background papers



Appropriate industrial technology in oils and fats industries: the case of Egypt

*K. E. Beyali**

Introduction

Industrialization in most developing countries is seriously handicapped by deep-rooted problems, notably the lack of a balanced technology system or the existence of one that is unbalanced and fragmented. At the same time, they suffer from drastic shortages of technical capabilities (including managerial skills), capital (particularly foreign), research and development (R and D) institutions and skilled labour. They face problems of rapid population growth and rural-urban migration, which add to the complications of social and political instability. These are only a few of the features characterizing the majority of developing and least developed countries. A few developing countries, however, have achieved a fairly rapid industrial development in the last two decades, establishing reasonably modern industries and in several cases have forced themselves into international markets in competition with foreign production. In the case of Mexico, for example, a well-prepared six-year plan was adopted for the development of science and technology in an attempt to lay the foundation of a national technology system, the presence of which is vital for the selection, transfer, adapation and application of technologies which, in this case, become appropriate.

The term "technology" needs to be defined to clarify its dimensions and the difference between it and the term "technique".

Technology is a total process involving all the systems and procedures of society, including the state as legislator and initiator of policies; the educational system and training institutions; investors (private and public) as sources of finance; the institutional set-up, including the administration, universities, R and D, documentation and information centres, the leadership (managers) who know how to combine capital, labour, raw material and appropriate technology for successful production in such a way as to assist in the socio-economic development of their countries; the holders of protected technology and know-how; and the public at large. In this sense technology becomes closely associated not only with science and research, but also with the totality of

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production factors, and the process of development as a whole (economic, social, political, ideological and value systems etc). It cannot be isolated from the total structure of the overall system, as it can only function and deliver its benefits to the society when it becomes one of the components of the whole machine. Thus, policies, institutions and legal instruments established for technology in a specific society at a specific phase of its development should be in harmony with and complementary to those established for the complete process of development of the country. This ensures the most efficient role of technology in the process and also the most efficient use of the techniques produced or adapted. Hence, as a prerequisite, the development objectives of the specific society should be carefully identified; they in turn provide the guidelines for the technology-development objectives and consequently the appropriate policies, institutions and legal instruments to be established. Imported technologies should necessarily respond to the requirements of this whole process.

In this sense, technology, as a complete process, cannot, in reality, be transferred. It is the products of the process, the techniques which are subject to the process of transfer and can be bought as commodities in the market. However, for the sake of simplicity, the term "technology" will continue to be used when what is really meant is techniques.

The following section defines appropriateness of technology for the purpose of this paper.

Appropriateness of technology

The extent of appropriateness of technology for development depends on the pattern and strategy of socio-economic development adopted by a country, whether developed or developing. In other words, technology must respond to the demands of the development process and resolve the problems facing it.

The appropriateness of technology for a given developing country at a certain phase of development can be generally judged by the extent to which the technology meets the following requirements, namely the engineering and other technicals aspects, the economic aspects and the social aspects.

All such aspects are, and should be, closely related to the demands of the socio-economic development plans and their specific strategies and objectives. Such aspects could be formulated as follows:

(a) The level of engineering and technical sophistication *vis-à-vis* the available skill level of operators and other production factors;

(b) The labour-skill structure available quantitatively and qualitatively in the country;

(c) The availability of maintenance facilities and possibilities of spare parts procurement, either locally or through imports, considering the adequacy or shortage of foreign currency needed for this purpose;

(d) Power and utilities available on site at reasonable economic cost;

(e) Suitability of techniques selected to locally available raw materials and flexibility of such technology for dual or multiple purposes;

(f) The most suitable economy of scale appropriate to the national development strategy adopted by the country;

(g) The optimization of input-output ratio of the technology selected;

(h) The maximization of output of fundamental consumption of goods and services and of the rate of growth;

(i) The reduction of balance of payments deficits and to what extent the purpose of foreign currency earning or foreign currency saving is served;

(j) The reduction of unemployment or underemployment;

(k) Greater equity of the distribution of income and improvement of the quality of life, especially in rural areas;

(l) The optimum utilization of natural renewable and non-renewable resources and of human resources;

(m) The ability to solve or avoid environmental and ecological problems;

(n) The promotion of political development and stability;

(o) The relevance to the cultural environment and social traditions;

(p) The participation in regional development;

(q) The relevance to the national pattern and strategy of development.

In economic terms, the selection of technology in any specific technology (or, more broadly in the development policy of a sector for a country) should conserve scarce resources and attain higher economic efficiency. It is understood that there must be some real opportunity for selection, the range of which involves the intensity of use of capital, labour and raw materials, provided that there exist engineering and organizational options to substitute one factor for another.

Selection of technology in this sense, of course, has complex repercussions that must be examined in detail before decisions are made and, with these fundamentals in mind, the judgement of the appropriateness of technology in the oils and fats industries will be made subsequently.

Transfer of technology

The basic assumption is that developing countries should benefit from the technologies already existing in the advanced countries instead of trying to reinvent them. If properly done, such transfer of technology can be of great help to the socio-economic development of developing countries.

In order to ensure that such transfer does not lead to adverse effects, the means, institutions and conditions necessary for the proper selection, negotiation, licensing, adaptation and application of the imported technology must be established.

As noted earlier, technology is not simply a set of technological information nor merely a set of equipment and tools or of products, whether goods or services. It is rather a complex system which contains information, know-how, equipment and products, as well as institutions, personnel, legislation and the process of innovation and application, with all these connected to the economic, social and political characteristics and objectives of society. Technological capacity and technological development must be understood in this comprehensive manner. Thus, the efficiency of and the benefits from the process of technology transfer are factors in establishing what we may call a "technological system".

Raw materials

Vegetable-oil industries depend for their supply of raw materials on what agriculture can provide in the form of oil-seeds, oil fruits and oil-bearing by-products. To draw up a policy for cultivating or expanding the cultivation of such crops, it is necessary to consider the following:

(a) The suitability of soils and climate;

(b) The comparative value of non-oil crops, an issue often of major importance where arable land is limited;

(c) The adequacy and quality of irrigation water (rain, artesian wells, springs, rivers and canals);

(d) The availability of suitable fertilizers, insecticides and pesticides;

(e) The cost of production including land rental, seeds, fertilizers, labour and the techniques in use;

(f) The post-harvesting operation, including packing, baling, transport and storage;

(g) The availability of trained labour for applying the chosen techniques and the adequacy of the motive power.

Outside influences

The crop or crops chosen for cultivation or expansion in their cultivation may not, however, be those giving the highest net agricultural economic return. The decision can be affected by such factors as developments in other industrial sectors, conservation of certain scarce resources, inherited social habits or the development of animal wealth.

Figures from the Egyptian Ministry of Agriculture (EMA), for example, show that the net returns from one feddan (4,200 m^2) in terms of values of cotton seed are insignificant compared with those of ground-nuts, sesame seeds, soya beans or linseed. Cotton seed is, however, Egypt's main source of oil and cake because cotton growing and cotton textile industries are vital to the economic structure of the country.

The market for oils and oil-cakes

In the world market, prices of oil-bearing materials and their products are mostly subject to fluctuating market forces. This has had a positive impact on the technological development of the industry. The development of the screw-pressing system, solvent extraction and continuous centrifugal refining were all undoubtedly affected by factors related to the prices of raw materials and products. Whether such technologies, developed by highly industrialized countries, are appropriate for developing countries is discussed later in this paper.

In several developing countries, prices and marketing policies are not subject to the normal market forces. The raw materials (oil-seeds) and the products (oil and cakes) are priced without regard to the world market.

In Egypt, for instance, cotton seed is artificially priced. While Sudanese (bulk) cotton-seed wholesale prices in European markets ranged between $97 per tonne in 1960 and $230 per tonne in 1974, Egyptian cotton seed was priced for the domestic market at a fixed level of $9.42 per tonne. This fixed price was imposed by the Government more than 30 years ago and still applies. Consequently, cotton-seed oil and cake were priced at about $71 per tonne of neutralized oil (bulk) and about $10.7 per tonne of undecorticated cake.[1] In the European market, cotton-seed oil prices ranged between $235 per tonne in 1960 and $939 per tonne in 1974. Undecorticated cotton-seed cake slabs ranged from $45 to $100 per tonne.

Hence, there has been a complete divorce of the price structures of raw materials and products in the European market and the Egyptian domestic market. This artificial pricing system was once justifiable and still is, in certain local conditions, but undoubtedly it has a negative effect on the industry in Egypt.

Two points to be remembered when examining these situations are, first, that in Egypt the industry has been almost totally State-owned since 1961, when it was nationalized; second, that since 1949 the selling prices of cotton-seed oil and cake were fixed on the basis of an artificial cost of cotton seed plus fixed-cost elements estimated at that time and which have not changed, despite inflation, plus a slim margin of profit, which was completely absorbed some years ago. These two considerations have prevented the oil-mills, management from enforcing their own policies and development plans or from using their marketing skills. The result has been an inability to replace outdated technologies, leading to declining efficiency. Realizing there was a crisis, the Government raised funds for renewal of the vegetable oil industries.

The industry has survived, it is suggested, by making product mixes and by selling by-products of low value at higher prices than they warrant. At the same time, high yields and improved quality have been encouraged by bonus payments by the Government.

Technological developments

The oils and fats industry is very old. History records the use of primitive presses to extract oils and fats in ancient China, Egypt and India. Similar presses still exist in many of the least-developed areas of the world. The quality of oil produced is low, the amount of waste is high, and the high content of residual oil in the cake causes it to deteriorate quickly and limits its use as animal feed.

[1]Decorticating is the removal of husk from seed, cake or meal.

Hydraulic presses were being built at the end of the seventeenth century. Though simple and relatively low in energy consumption, these presses were at a handicap in areas where labour was either scarce or costly. R and D activities, facing the challenge of such handicaps, led to the development of screw-presses (expellers), the operation of which, though higher in energy consumption, was labour saving. Such technology better suited conditions in areas where energy was relatively cheap and labour was short, but more skilled. Such areas were, generally speaking, in highly industrialized countries, though the technology proved suitable for many of the less industrialized countries.

In choosing between these two technologies one actually needs to do much more than compare energy and labour requirements. All the elements previously outlined in this paper should be dealt with.

The residual oil in cakes produced in both hydraulic and screw-pressing operations was important, not only because of economic factors, but also because of the continuous increase in the demand for oils and fats by a growing population and the gradual improvement in living standards in developing areas. Although large-capacity and heavy-duty expellers succeeded in reducing the residual oil, in same cases to as low as 3 per cent, this was at the expense of the higher power costs for running such presses. R and D later reduced the figure to as little as 1 per cent or even less. Solvent-extraction technology was also introduced. In high oil-content seeds, screw-pressing was combined with solvent extraction. Oils and fats refining, aimed at improving the quality of oils and fats used for human food, was also developed. For instance, simple open-kettle caustic refining was improved by earth bleaching and deodorization. Continuous centrifugal caustic refining also reduced refining losses and made oils easier to bleach. (However, when it comes to a decision on which is more appropriate as an alternative technology, it is advisable not to limit the comparison to this narrow area but also to include the other factors of appropriateness.)

Open-kettle batch bleaching and vacuum-kettle deodorizers were developed into continuous operations, with several economic and technological advantages.

A major characteristic of vegetable oils and fats is the way they are linked with many other industries. Production of hydrogenated oils for edible and industrial purposes is founded mainly on oils and fats. The hydrolysis of oil for the production of fatty acids for making soap and glycerine is directly related to oils and fats. Paints and varnishes obtain many of their primary materials from the products of oils and fats processing. The cakes and meals produced as by-products of oil extraction are important ingredients of balanced-formula feeds for cattle and poultry, thus serving, in turn, other industries such as meat-packing, fat-rendering and the dairy industry. Processed cakes and meals also produce fractions utilized as a supplementary source of protein for human nutrition. The husks produced as a by-product in hulling operations have also a value when burnt in boilers for energy generation or for use as soil conditioners. They can also be fermented for the production of furfural.

In sum the industry based on the extraction and refining of oils and fats constitutes a broad foundation for socio-economic development in countries varying from the least developed to the most highly industrialized.

Egyptian oils and fats: a case study

A good presentation of the problems of finding the most appropriate technology in the oils and fats industries can be made by a study of their development in Egypt.

Background

Before cotton was introduced to Egypt in the early nineteenth century, the main sources of oils were flax (linseed) and sesame, which were crushed in animal-powered stone crushers. Similar machines are still in use in some Egyptian villages. The crude sesame oil produced in Egypt, mainly by this process, is popularly called *Serig* oil and is still used in rural and some urban areas. The same technology is also used for crushing considerable quantities of linseed for the production of what is popularly called *Har* oil. In the last 20 years, many small electrically operated screw-presses have been introduced. They are more efficient and more economic.

At first, with the introduction of cotton in Egypt, cotton seed appeared on the market, but only for export. Towards the end of the century, the first hydraulic-press mill was set up in Alexandria for crushing part of the crop and exporting the products. With the expansion of cotton growing, other mills were established near Alexandria and along the Nile valley.

Most of the mills used hydraulic presses, with some screw-presses being used for crushing linseed. The oil refining in all but one of these mills was open-kettle caustic refining and batch bleaching and deodorization.

Following the almost complete nationalization of this industry in 1961 and 1963, planning for its development and modernization took place, aimed at:

(a) Amalgamation of small oil-milling factories into a smaller number of large-capacity mills;

(b) Gradual abolition of the hydraulic pressing system, and its replacement by direct solvent-extraction or by pre-pressing and solvent extraction;

(c) Replacement of the caustic open-kettle refining system by the continuous centrifugal system;

(d) Replacement of the batch systems of bleaching and deodorization by continuous systems;

(e) Expansion of polyvinyl chloride (PVC) bottling of refined oil rather than distribution in iron barrels;

(f) Installation of continuous soap-making and packing processes;

(g) Expansion of the capacities of the glycerine water concentration and refining vats to process all the glycerine water produced in soap plants;

(h) Expansion of the production of pelleted mixed feed to use all the cake produced in the oil mills in addition to other feed materials;

(i) Setting up solvent-extraction mills for extracting oil from rice bran;

(j) Setting up ventilated cotton-seed stores.

In the following 10 years all these plans were gradually realized with the exception of the ventilated cotton-seed stores, of which only one was built, using local building materials and technology.

Meanwhile, other improvements had been made, including, in some plants, the replacement of hydrogen-production battery systems and margarine-production batch systems by continuous systems and the renewal of fatty acid distillation equipment.

The amalgamation of small oil-mills into a smaller number of large-capacity ones showed a shift from a policy of decentralization to one of centralization, in which the larger units became more or less industrial oil complexes, including several operations beginning with oil extraction and ending with several oil products. There were few employment problems because most of the workers in the small mills simply moved to the larger units.

Cotton-seed technology

The technologies which were and are used in Egypt are hydraulic, direct solvent extraction and pre-pressing followed by solvent extraction. All of these techniques had been developed and improved in the industrialized countries and were applied basically in their original forms.

For this reason any assessment of the appropriateness of these technologies is not, in fact, a comparison between them and different technologies generated locally. It is, in essence, a study of the relative appropriateness of three imported technologies, namely, the hydraulic press system, the direct solvent-extraction system and the pre-press and solvent-extraction system, applied almost as they were originally developed in industrial countries. (See annex IV for an assessment of the three technologies used in Egypt for crude cotton-seed oil extraction.)

The following may be stated as a clear diagnosis of the industry at present:

(a) Oil seed extraction (mainly cotton-seed), using hydraulic presses, screw-pressing, solvent extraction, and pre-pressing combined with solvent extraction;

(b) Oil refining using open-kettle process and centrifugal continuous refining, open kettles and continuous bleaching, and vacuum deodorization (batch and continuous);

(c) Hydrogenation for the production of edible shortening, margarines and ghee and of non-edible hydrogenated oils for making soap and other products;

(d) Laundry- and toilet-soap using open kettles and continuous centrifugal processes (see annex I for an assessment of two technologies used in Egypt for saponification);

(e) Fat-splitting for the production of fatty acids and glycerine, including fatty acid distillation (see annex II for an assessment of two technologies used in Egypt for the distillation of glycerine);

(f) An animal feed industry for the production of balanced rations in powder and pellet forms (see annex III for an assessment of two technologies used in Egypt for the production of animal feed);

(g) A paint and varnish industry.

Engineering aspects of appropriateness

Without going into details of the extent of engineering sophistication of one technology developed after the other, one could generalize and say that the hydraulic-press technology is less sophisticated compared to the screw-press system, and this latter system is, in turn, less sophisticated than both the direct solvent-extraction and the pre-press and solvent-extraction systems. This fact is confirmed by several indicators shown in annex IV, among them:

Electrical energy used per worker

Electrical energy used per tonne of seed crushed

Initial cost of equipment per worker

The ratio of the initial cost of equipment to total salaries and wages

Consumption of utilities per tonne of seed crushed and per tonne of crude oil produced

Cost of repairs, maintenance and spare parts per tonne of seed crushed and per tonne of crude oil produced

It is to be noticed that the figures stated in the column for pre-press and solvent extraction show low levels of costs, which may indicate an abnormality relative to the high level of engineering sophistication. The company that operates this technology is one of the largest complexes in this industry and is equipped with complete maintenance shops, a skilled technical staff and good management.

The company was thus able to economize on the costs of repair and maintenance operations and on the costs of spare parts, many of which were manufactured in their own workshops or at others within Egypt.

The different levels of engineering sophistication in the three technologies considered in annex IV were not a problem from the point of view of the skill of the available workers in Egypt. There was a shortage, for a time, when many of them were attracted by higher salaries abroad, mainly in the oil-exporting Arab countries. This difficulty was overcome by intensive training programmes arranged by the Government and by the companies.

For many years Egypt has suffered from a considerable shortage of foreign exchange. Although a serious handicap, it encouraged local workshops to make reasonably good-quality spare parts and replacements for machinery and equipment. It did not, however, proceed into adaptation and generation of new local technologies.

The appropriateness of a technology may also be measured by the employment opportunities that it offers; employing a person who would otherwise be out of work, is a net gain for the economy. With this in mind, it is clear that the hydraulic press is relatively appropriate in Egypt, since this system employs more labour than the two other systems combined.

In developing countries, decentralization of industry into rural areas is often advocated as a means of creating jobs. As previously mentioned, the development plans for this industry in Egypt were, on the contrary, based on centralization. The justification was that the social factor of employment was offset by the more important demand for efficient operations that would extract the highest oil yields from the limited quantities of cotton seed and other oil-bearing materials produced in Egypt, bearing in mind the continuously increasing *per capita* consumption. Egypt, being short of foreign currency, could not afford to neglect the high residual oils in cotton-seed cakes, replacing them with imported substitute oils or additional oil-seeds. Another consideration was the absence, on the world market, of economic low-cost, small-scale foreign technologies suitable for the application of a policy based on decentralization. At the same time, no local technologies were developed for this purpose, partly because, until recently, power sources were not available in many rural areas where oil-seeds were grown. In other words, the industry is still changing, and it is not yet clear whether, with its present structure and technologies, it is providing an appropriate number of jobs.

Added value

The three technologies assessed in annex IV can be compared in several ways, including the total of the value added in each. This will be based on the production costs and the profit. In Egypt, the least expensive system is pre-pressing and solvent extraction comes next and hydraulic pressing is the most expensive, in the approximate ratios 5:6:8.

As the selling prices of cotton-seed oil and cake are fixed by the Government, profitability is naturally higher with pre-pressing and solvent extraction. In turn, the amount of value added in each case is related to the profitability.

Productivity factors in each of the three technologies may also be of interest in discussing the economic aspects of their relative appropriateness. According to available figures, although the initial equipment cost is higher, the direct solvent extraction system gives the highest values of products as measured against the number of workers and the cost of wages.

Neutralization and partial bleaching

Egypt has two systems for cotton-seed oil neutralization and partial bleaching: open-kettle batch caustic refining and continuous centrifugal refining.

The open-kettle batch system was developed several centuries ago and, being simple in design, it could be considered an intermediate technology. The simplicity of its design enabled many developing countries to manufacture its components and even to introduce minor improvements. However, for it to produce good results in processing crude oil, high skill in the operator is needed. The continuous centrifugal system removed this need by greater mechanization and control.

However, the centrifugal system was developed in industrialized countries, and few, if any, modifications were introduced into it by users in developing countries, who remain dependent to a great extent on the makers for spare parts and replacements. (See annex V for an assessment of two technologies for the caustic refining of crude cotton-seed oil.)

In a comparison of the two technologies, the continuous centrifugal system is characterized by considerable engineering sophistication. This means higher installation and running costs. At the same time, it does not create any serious difficulty with regard to the availability of skilled labour. However, in general employment terms, the newer system provides fewer opportunities. While 51 workers (including three engineers, three technicians and 24 skilled employees) were needed to run a 4,500 t/a crude oil input-capacity open-kettle plant, only 24 workers were needed to run a continuous centrifugal plant of double the input capacity. Also, all the workers in the latter plant were literate; the minimum qualification was an ability to read and write. The continuous centrifugal technology thus failed to provide more employment opportunities, but this was compensated by lower average refining losses and several other cost savings. The centrifugal system is cheaper to run and adds more value than batch refining.

The economic aspect

In line with what has been said previously, concerning the economic aspect of appropriateness in the technologies applied for extracting crude oil from cotton seed, one may also state here that the operation costs in the refining of crude oil in the continuous centrifugal system are considerably lower than that in the batch refining. The value added may also record another economic advantage for the centrifugal system.

The value of products per worker and per dollar of total salaries and wages shows a considerable economic advantage for the centrifugal system over the batch system, which justifies its application.

Annex I

Assessment of two technologies used in Egypt for the saponification operation in laundry-soap manufacture

Item	*Batch (open-kettle) method*	*Continuous centrifugal system*
Input capacity of tallow and oils (t/a)[a]	14 400	14 237
Actual capacity utilized (t/a)	12 960	12 999
Utilization factor (%)	90	91.3
Laundry soap produced (t/a)	18 000	21 000
Ratio of product to raw material (%)	140	160
Personnel		
Professional and semi-professional	*1*	*8*
Engineers (university degree)	–	4
Technicians (technical school)	1	4
Skilled	*4*	–
Primary-school certificate	4	–
Literate	–	–
Illiterate	–	–
Semi-skilled	*8*	*4*
Literate	8	4
Illiterate	–	–
Unskilled	*16*	*8*
Literate	–	8
Illiterate	16	–
Total	29	20
Salaries and wages (dollars per annum)		
Total operation	13 786	10 694
Average per worker	475	535
Average per tonne of product	0.77	0.51
Marketing		
Average per tonne of product	0.37	0.32
Overhead		
Average per tonne of product	2.58	2.21
Utilities and maintenance (dollars per annum per tonne of product)		
Electricity	0.27	1.14
Steam	4.92	0.57
Water[b]	0.018	0.014
Spare parts	0.12	0.18
Repairs and maintenance	0.73	0.45
Lubrication and greasing	0.021	0.164
Extent of mechanization		
Initial cost of equipment ($)[c]	91 885[c]	498 571
Initial cost per worker ($)	3 168	24 928

Item	*Batch (open-kettle) method*	*Continuous centrifugal system*
Ratio of initial cost to salaries and wages	6.7	46.6
Electrical energy used per worker (kWh/a)	2 483	10 800
Electrical energy used per tonne of product (kWh/a)	4.0	10.3
Productivity norms		
Value of products per worker ($)	89 464	151 344
Ratio of product value to total salaries and wages	188	283
Ratio of product value to interest cost of equipment	28.2	6.1

[a] Assuming a year of 300 working days and a single shift.

[b] The cost of water used in the process is exceptionally low because it is artesian on site.

[c] The large difference between the initial costs of equipment in both technologies is due to the fact that the open-kettle batch technology was purchased and installed about 30 years ago, when prices were lower.

Annex II

Assessment of two technologies used in Egypt for the distillation of glycerine[a]

Item	*I*	*II*
Input capacity (t/a of 80% glycerine)[b]	1 300	2 500
Actual capacity utilized (t/a)	1 129	2 160
Utilization factor (%)	87	86
Distilled glycerine produced (t/a)	600	1 500
Ratio of product to raw material	53	69
Personnel		
Professional and semi-professional	5	5
Engineers (university degree)	1	1
Technicians (technical school)	4	4
Skilled	*4*	*4*
Primary-school certificate	4	4
Literate	–	–
Illiterate	–	–
Semi-skilled	*4*	*4*
Literate	4	4
Illiterate	–	–
Unskilled	–	–
Total	13	13
Salaries and wages (dollars per annum)		
Total operation	8 571	10 000
Average per worker	659	769
Average per tonne of product	14.3	6.7

Assessment of two technologies used in Egypt for the distillation of glycerine[a] *(continued)*

Item	*I*	*II*
Marketing		
Average per tonne of product	4.03	1.61
Overhead		
Average per tonne of product	28 338	11 335
Utilities etc.		
Electricity (dollars per annum per tonne of product)	1.40	1.40
Steam	7.71	7.71
Water	0.95	0.95
Spare parts		0.34
Repairs and maintenance	5.15[c]	1.57
Lubrication and greasing	–	–
Depreciation	3.48	18.33
Packing	51.32	51.32
Extent of mechanization		
Initial cost of equipment ($)	38 907	133 640
Initial cost per worker ($)	2 992	10 280
Ratio of initial cost to salaries and wages	4.5	13.4
Electrical energy used per worker (kWh/a)	4 509	11 273
Electrical energy used per tonne of product (kWh/a)	97.7	97.7
Productivity norms		
Value of products per worker ($)	26 374	65 934
Ratio of product value to total salaries and wages	40	85.7
Ratio of value of products to initial cost of equipment	8.8	6.4

[a] The difference between the technologies I and II is that in I the condensation of glycerine takes place in condensers cooled by glycerine at temperatures between 130° and 140° C. In II, the condensation of glycerine takes place in air-cooled condensers.
[b] Assuming a year of 300 working days and a single shift.
[c] Including spare parts.

Annex III

Assessment of two technologies used in Egypt for the production of animal feed

Item	*Manual*	*Semi-mechanical*
Input capacity (t/a)[a]	25 000	60 000
Actual capacity utilized (t/a)	23 621	58 800
Utilization factor (%)	94	98
Animal feeds produced (t/a)	23 000	58 391
Ratio of product to raw material	97	99

Item	Manual	Semi-mechanical
Personnel		
Professional and semi-professional	*20*	*15*
Engineers (university degree)	4	3
Technicians (technical school)	16	12
Skilled	*44*	*12*
Primary-school certificate	24	6
Literate	20	6
Illiterate	–	–
Semi-skilled	–	*13*
Literate	–	13
Illiterate	–	–
Unskilled	*160*	*11*
Literate	–	–
Illiterate	160	11
Total	224	51
Salaries and wages (dollars per annum)		
Total operation	111 075	28 571
Average per worker	496	560
Average per tonne of product	4.83	0.49
Marketing		
Average per tonne of product	0.09	0.35
Overhead		
Average per tonne of product	0.718	0.283
Utilities etc. (dollars per annum per tonne of product)		
Electricity	0.161	0.317
Steam	0.185	0.185
Water	0.007	0.007
Spare parts	0.107	0.185
Repairs and maintenance	0.624	0.17
Lubrication and greasing	0.015	0.025
Packing	0.487	0.487
Depreciation	0.183	0.355
Extent of mechanization		
Initial cost of equipment ($)	44 160	243 197
Initial cost per worker ($)	197	4 769
Ratio of initial cost to total salaries and wages	0.4	8.5
Electrical energy used per worker (kWh/a)	933	21 765
Electrical energy used per tonne of feed (kWh/a)	9.1	19.1
Productivity norms		
Value of products per worker ($)	2 483	24 790
Ratio of value of products to total salaries and wages	3.5	31.0
Ratio of value of products to initial cost of equipment	8.8	3.6

[a] Assuming a year of 300 working days and a single shift.

Annex IV

Assessment of the three technologies used in Egypt for crude cotton-seed oil extraction

Item	*Hydraulic press*	*Direct solvent extraction*	*Pre-press and solvent extraction*
Input capacity (t/a)[a]	60 000	54 000	135 000
Actual capacity utilized (t/a)[b]	35 832	31 976	91 570
Utilization factor (%)	60	59	68
Crude oil produced (t)	5 062	5 735	16 788
Crude oil recovery (percentage of seed)	14.1	17.9	18.3
Personnel			
Professional and semi-professional	*13*	*11*	*22*
Engineers (university degree)	5	5	5
Technicians (technical school)	8	6	17
Skilled labour	*80*	*15*	*26*
Primary-school certificate	–	5	26
Literate	31	10	–
Illiterate	49	–	–
Semi-skilled	*100*	*14*	*64*
Primary-school certificate	–	–	–
Literate	–	14	64
Illiterate	100	–	–
Unskilled	*15*	*4*	*16*
Literate	–	–	–
Illiterate	15	4	16
Total	208	44	128
Salaries and wages (dollars per annum)			
Total operation	78 727	24 020	62 050
Average per worker	380	546	485
Average per tonne of seed	2.19	0.75	0.67
Average per tonne of crude oil	15.55	4.18	3.69
Marketing			
Average per tonne of seed	0.19	0.04	0.24
Average per tonne of crude oil	1.32	0.18	1.29
Overhead			
Average per tonne of seed	0.56	0.23	0.72
Average per tonne of oil	3.97	1.30	3.90
Utilities etc. (dollars per annum)			
Electricity			
Per tonne of seed	0.14	0.26	0.49
Per tonne of crude oil	0.96	1.44	2.67
Steam			
Per tonne of seed	0.43	1.84	1.06
Per tonne of crude oil	2.98	10.12	5.99
Water			
Per tonne of seed	–	0.14	0.15
Per tonne of crude oil	–	0.77	0.80

Item	*Hydraulic press*	*Direct solvent extraction*	*Pre-press and solvent extraction*
Spare parts			
Per tonne of seed	0.38	1.07	0.05
Per tonne of crude oil	2.68	5.91	0.32
Repairs and maintenance			
Per tonne of seed	1.46	2.13	0.85
Per tonne of crude oil	10.22	11.75	4.59
Lubrication and greasing			
Per tonne of seed	0.01	0.22	0.02
Per tonne of crude oil	0.07	1.23	0.12
Packing			
Per tonne of seed	0.05	0.06	0.05
Per tonne of crude oil	0.38	0.35	0.29
Dispatching			
Per tonne of seed	0.28	0.62	0.10
Per tonne of crude oil	1.99	3.40	0.56
Depreciation			
Per tonne of seed	0.06	1.54	0.35
Per tonne of crude oil	0.41	8.51	1.88
Extent of mechanization			
Initial cost of equipment ($)[c]	91 800	426 400	190 000[b]
Initial cost per worker ($)	441	9 690	1 485
Ratio of initial cost of equipment to total salaries and wages	1.7	25.4	4.4
Electrical energy used per worker (kWh/a)	378.50	15.909	13 604
Electrical energy used per tonne of seed crushed (kWh/a)	2.20	21.89	19
Productivity norms			
Value of product per worker ($)	1 565	8 380	4 684
Ratio of value of products to total salaries and wages	5.9	21.9	17.4
Ratio of value of products to initial cost of equipment	5.1	1.2	5.7

[a] Assuming a year of 300 days and a single shift.

[b] Relatively low owing to limitations of cotton-seed quotas imposed by the Government and lack of freedom of the management to import additional quantities.

[c] The initial cost of the pre-press and solvent-extraction systems relative to its yearly input capacity is much lower than that of the much smaller direct solvent-extraction system because the former was purchased about 30 years ago, when prices were much lower, while the latter was purchased in the 1960s. The hydraulic press was purchased even earlier than the pre-press and solvent-extraction systems. Consequently, changes in price levels must be considered when evaluating any of these indicators.

Annex V

Assessment of two technologies for the caustic refining of crude cotton-seed oil

Item	*Batch method*	*Continuous centrifugal system*
Input capacity (t/a)[a]	4 500	9 000
Actual capacity (t/a)	3 638	9 000
Utilization factor (%)	75	100
Neutralized oil produced (t/a)	3 384	8 600
Average refining loss (%)	7.5	4.4
Personnel		
Professional and semi-professional	*6*	*8*
Engineers (university degree)	3	4
Technicians (technical school)	3	4
Skilled	*24*	*4*
Primary-school certificate	–	–
Literate	24	4
Illiterate	–	–
Semi-skilled	*15*	*4*
Literate	5	4
Illiterate	10	–
Unskilled	*6*	*8*
Literate	–	8
Illiterate	6	–
Total	51	24
Salaries and wages (dollars per annum)		
Total operation	24 000	12 567
Average per worker	471	527
Average per tonne of crude oil	6.60	1.41
Average per tonne of neutralized oil	7.09	1.47
Marketing		
Average per tonne of neutralized oil	0.63	0.71
Overhad		
Average per tonne of neutralized oil	1.81	4.84
Utilities etc. (dollars per annum per tonne of neutralized oil)		
Electricity	0.09	0.15
Steam	1.38	1.03
Water	0.09	0.04
Spare parts	0.24	0.13
Repairs and maintenance	0.78	0.14
Lubrication and greasing	0.08	0.05
Depreciation	0.60	0.77
Extent of mechanization		
Initial cost of equipment ($)	20 593	66 343
Initial cost per worker	404	2 764
Ratio of initial cost of equipment to total salaries and wages	0.86	5.24
Electrical energy used per worker (kWh/a)	341.3	3 834

Item	*Batch method*	*Continuous centrifugal system*
Electrical energy used per tonne of neutralized oil (kWh/a)	6.5	10.7
Productivity norms		
Value of products per worker ($)	4 711	25 442
Ratio of value of products to total salaries and wages	10.0	48.2
Ratio of value of products to initial cost of equipment	11.7	9.2

[a]Assuming a year of 300 working days and a single shift.

Problems of raw materials acquisition in Ghana

*K. Poku**

This study examines the problems of the oils and fats industry in Ghana in connection with the supply of appropriate raw materials and the appropriate technology for processing them. It is based mainly on the experience of a company that has an oil-milling capacity of 100 t/d but is using only about 5 per cent of that capacity.

The reasons for underutilization of capacity are these:

(a) First, the mill lacks a vegetable-oil refinery and the equipment for seed preparation and has been limited to processing of ground-nuts and palm kernels. With a refinery, it could process other readily available seeds such as soya beans and cotton seed. Filtered oils from these seeds cannot be used for direct human consumption without refining;

(b) Second, local supplies of raw materials are inadequate, for several reasons which are examined later in this paper;

(c) Third, even when the raw materials are available, they are difficult to procure. Part of the problem here is the poor transport network and other infrastructural facilities.

The company has almost completed plans for the establishment of a refinery. The main outstanding concern is therefore one of securing the appropriate raw materials.

Raw materials

The low throughput of the plant led the company to look at the raw materials situation to consider possible remedies. To justify a refinery it was necessary to diversify its raw-materials base to include cotton seed, shea nuts and soya beans. The problem is that even though these exist, their collection is not easy. It is proposed to examine the special problems of each of the main oil-seeds.

Ground-nuts

These are cultivated on a commercial basis, mainly in the Northern and Upper regions of the country, with small subsistence cultivation in the Eastern, Ashanti and Volta regions.

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In the south, the harvest is almost all for direct consumption. The processing mills and the traditional contractors look to the Northern, Brong-Ahafo and Upper regions for their supplies. Of the estimated 45,000 t of ground-nuts produced annually about 75 per cent comes from these regions. However, there are three major problems for firms entering the market:

(a) Stiff price competition from the traditional processors and smugglers;

(b) A poor road network;

(c) Attraction of other cash crops and the price control as finished products imposed by the Prices and Incomes Board of Ghana.

The traditional processors and middlemen in the trade are mostly residents in the area who live quite close to the farmers and help them with loans and other services. The middlemen, by virtue of their unique relationship with the farmers, are in a position to pre-empt a substantial part of the production, which they sell to the traditional extractors who, depending on market conditions, either sell the seeds or process them. There has also been scarcity because of famine, which has encouraged smuggling.

Some of the processing units have gained access to supplies by offering loans and services to the farmers. It is felt the continued success of such schemes will depend largely on the availability of improved seeds with high oil content, of fertilizers, tractors and land clearing equipment and of facilities for repair and maintenance of farm equipment. One company has decided to enter the farming arena directly with 600 acres (243 ha) used for growing seedlings for supply to "outgrowers" and also to demonstrate modern methods of cultivation. There is, meanwhile, still some resistance from small-scale farmers to ground-nut cultivation because of other attractive cash crops. Areas most suitable for ground-nuts are also those that can effectively support cotton, rice and maize.

Palm kernels

Palm trees grow widely, both wild and in plantations. With the introduction of the outgrower schemes and the active support of the banks, it is expected that private plantation holdings will increase in number.

There are three categories of suppliers of palm kernels: established private palm-oil factories and the State farms, individual farmers who also process their palm oil in the farms or in surrounding villages, and wild-palm collectors.

Buying from the mills directly tends to lead to higher prices because of the increased demand. Buying from medium-scale producers has been found to work well if the price is right and prompt payment is made.

The real problem lies with the scattered group suppliers. To handle them agents have been appointed in various towns and villages to buy on a contract basis, with a commission. Transport must then be arranged.

Unfortunately, with palm kernels, most of the nuts go to waste. Some mills burn entire palm kernels, instead of just the shells, for fuel. Many palm kernels are thrown away because there is no organized purchasing of unshelled palm kernels. Most processors prefer shelled nuts because shelling represents a slow, painstaking job for the producers.

Soya beans

This is not an important crop in Ghana at present, but with the establishment of the Grains Development Board, it is expected to increase in importance. One reason for the slow development and cultivation of soya beans has been lack of interest by prospective processors. The Government would like to see more soya beans grown for animal feed so as to encourage the country's livestock industry.

However, because there is a limited local market and soya beans are not used in the local diet, it may be difficult to hold the interest of farmers. Soya beans, like other annual crops such as ground-nuts and sesame seed, tend to be abandoned by farmers unless the mechanized inputs are readily available.

Shea nuts

Shea nuts grow wild in the Northern and Upper regions of the country. The Ghana Cocoa Marketing Board (GCMB) is the only organized body in the country whose declared annual purchases (to 9,000 t in 1975/76) can give an indication of the size of the crop. GCMB has been exporting shea kernels to Belgium, the Federal Republic of Germany, Japan, Luxembourg, Sweden and the United Kingdom.

The figures as reflected in the purchases made by GCMB vary widely from year to year. The fluctuation is explained by the fact that the quantities of shea trees growing wild and the quantity of shea nuts harvested are dependent not only on the weather conditions but also on the willingness of the local people to collect the nuts for sale. One estimate suggests that more than twice the amount of shea nuts sold to GCMB is smuggled out of the country.

Cotton seed

Since the Cotton Development Board is the sole purchaser of cotton in Ghana, procurement of cotton seed would not present any problem, provided an understanding could be reached with that Board to sell the seed.

Conclusions and recommendations

Conclusions

The problems can be summarized as follows:

(a) Competition from middlemen, traditional extractors and smugglers;

(b) The poor prices paid by the factories owing to the limitations imposed by the Prices and Incomes Board on the selling price of finished goods;

(c) Lack of an organized market;

(d) Lack of incentives for the production or collection of the oil-seeds. This is linked also to the pricing problem;

(e) Poor transportation and infrastructure;

(f) Unnecessary competition between the factories themselves and inter-ministerial rivalries;

(*g*) Lack of co-ordination in the activities of the oil-seed industry as a whole.

Recommendations

For proper planning and a co-ordinated development of the industry, an important measure would be to establish a single Oils and Fats Industry Board in place of the existing separate commodity boards. Such a board would be responsible for the following functions:

(*a*) Organization of farmers within areas acquired by the Government (for the Board) for the cultivation of specific oil-seeds;

(*b*) Supply of planting materials, fertilizer, farm machinery, machinery, maintenance workshops and any other necessary inputs to farmers;

(*c*) Provision of extension services and the arrangement of credit facilities for farmers with the commercial and specialized banks;

(*d*) Becoming the sole agency responsible for the purchase and prompt payment for all oil-seeds (except cocoa) produced in the country;

(*e*) Distribution of imported or locally purchased oil-seeds to local factories for processing, the export of surplus oil-seeds and the regulation of prices of both raw materials and finished goods;

(*f*) Co-ordination and supervision of new processing facilities;

(*g*) Research and development (R and D) of oil-seeds, their cultivation and processing and further use of oils, soaps, paints, detergents etc., and cake for animal feed;

(*h*) Linking the country and foreign institutions in the transfer of technology and financial aid for the development of the oils and fats industry;

The existence of an oils and fats industry board should:

(*a*) Improve planning, organization and control of the industry;

(*b*) Help to encourage an equitable transfer of income from the urban, higher-income population (who consume the refined oils, soaps etc.) to the rural, less affluent farmers and thus raise the living standards of the rural population;

(*c*) Provide a system of buying farm products at prices which would generate confidence in the farmer to increase his output, knowing that his products would be saleable;

(*d*) Ensure that the factories are adequately supplied with raw materials without the current problems;

(*e*) Stimulate processing techniques which could reduce the losses in edible oil and cakes encountered by traditional methods (the traditional extractors could be redeployed in the profitable cultivation of oil-seeds);

(*f*) Enforce stricter controls on exports, thus reducing the activities of smugglers.

Technological improvement of the oils and fats industry in Ghana has been hampered by the problems of availability of appropriate raw materials. Reorganization on the lines set out above could open up the path to new technological innovations. For example, most of the oil mills in Ghana are of the mechanical expeller type. However, it is felt there are enough raw materials in the country to feed and sustain a small solvent-extraction plant if the raw materials market could be stabilized, and the change from traditional extraction methods does not result in large-scale displacement of manpower.

The employment problem could be eased by relocating the existing mechanical mills displaced by the solvent extraction plant, to rural areas. This would then offer new employment to the affected traditional extractors who could be grouped into co-operatives to run the new factories.

The addition of the solvent-extraction plant would also offer the opportunity for the purchase and further processing of expeller cakes from the mechanical mills as well as the traditional extractors.

This arrangement would have several advantages:

(a) The raw materials base could be increased indirectly by the inclusion of the cakes, which would normally be thrown away by traditional extractors;

(b) It would enable the recovery of otherwise lost oil from the cakes and also the production of low-fat meals for animal-feed compounding;

(c) It would allow traditional extractors to stay in business and earn more income from their cake sales and forestall the possible displacement of rural manpower;

(d) It would encourage the dispersal of mechanical mills to rural areas, which would generate more interest on the part of the farmers to produce more raw materials once they became aware that there was a ready local market for their produce.

Appropriate technology for the production and processing of oils and fats industry in India

*K. T. Achaya**

Production of oil

Mustard and sesame oils have apparently been used in India from very early times. The oils and fats industry represents, in fact, a traditional technology which has served the needs of people for thousands of years. Since 1900, older methods have been joined by modern technologies of various levels of sophistication. In consequence, the picture is a complex one. Tiny traditional ghanis[1] for oil-extraction, using animal power, exist alongside power-driven plants. Since about 1930, power expellers have been in use followed later by solvent-extraction units.

Estimates made by the Universtiy of Bombay, the Regional Research Laboratory, Hydrabad,[2] and the Council of Scientific and Industrial Research, New Delhi,[3] show that India has between 200,000 to 300,000 village ghanis.

There are believed to be about 50,000 power-driven ghanis, about 15,000 unpowered and 500 to 600 powered oil expellers, and nearly 200 solvent-extraction units. In terms of oil production, the village ghanis and the unpowered expellers each contribute about 35 per cent, and the powered expellers about 20 per cent. The remaining 10 per cent comes from improved ghanis and solvent-extraction units. Broadly, the tiny units represent village ghanis, the small-scale (with capital outlays of between Rs 100,000 and Rs 1 million) mostly powered expellers, and the large-scale, mostly solvent-extraction units.

It is interesting to note that the ratio of capital to output is as low as 0.41 for the smaller units but up to as much as 1.25 for the large-scale units. Thus, not only are the capital needs for small units small in themselves, but in terms of production this capital is used about three times as efficiently as in the large-scale units. The job-creating potential of the small units cannot, however,

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[1]The ghani is a traditional Indian mechanical oil-seed pressing device. It is still in use, mainly in the north of India, for processing rape and mustard seeds. The oil-seed is pressed against the walls of a rotating steel container by a wooden stem.

[2]*Study on Oilseeds Sector: Processing and Utilization of Oilseeds and Products* (Hyderabad, Regional Research Laboratory, May 1976).

[3]*Vegetable Oils*. The Wealth of India: Industrial Products (New Delhi, Council of Scientific and Industrial Research, 1976).

be considered very high. On an average, each employs about 20 persons, while the large units employ about 130.

Supply of raw materials[4]

The tiny village ghanis, lacking ready capital, depend for their supply of seed on the village traders, who obtain their supplies from the farmers through commision agents.

The expelling units generally buy their oil-seeds from the markets through larger commission agents. Almost every season, there comes a time when the prices of oil begin to fall and the farmer is forced to sell cheaply. The growth of regulated markets in the terminal market centres has, however, helped the farmers to have a better knowledge of price trends. They can then set their own selling prices after allowing for costs of transport, commission and so on.

The solvent-extraction industry uses oil-cake as raw material, either from its own production or derived from outside expeller units. Being more sophisticated industries, these units are able to set prices on the basis of analytical data such as oil and protein content and on likely returns for the product.

Use of oils

In 1975/76, India produced about 3 million tonnes of oil, of which a little over 500,000 t were non-edible oils for the soap, paint and other industries. Of the rest, about 600,000 t, go towards *vanaspati*[5] manufacture, and 100,000 t for export, leaving a little over 2 million tonnes for dietary use.

Oils are sold in two ways: as unrefined oil, which is sold unpackaged and as refined oil, which is generally packed in tins under various brand names. Usually ghani-derived oil is sold locally in unrefined form. Expeller oil is mostly refined, as is all solvent-extracted oil. On the basis of returns from factories making edible-oil products and on production data for both hydrogenated fat and refined oils from *vanaspati* factories, it would seem that about 40 per cent of all edible oil in India is consumed in the unrefined or crude form. The possibilities of alternative technologies and their implications may now be considered.

Ghani technology

The most common criticisms of traditional technologies are inefficiency, poor recovery and low product quality. In the vegetable-oil industry, this need not be a drawback any longer, since solvent extraction of ghani oil-cake will extract all the oil that remains (13 to 14 per cent).

[4]P. S. George, U. K. Srivastava and B. M. Desai, *The Oilseeds Economy of India* (India, Macmillan, 1978) p. 39.

[5]*Vanaspati* is a purified hydrogenated vegetable oil used in India and is similar to margarine. It is fortified with vitamin A.

Improving the efficiency of the ghani would, of course, bring better returns to the village entrepreneurs. If the oil is left in the cake, the benefit goes to the solvent extractor.

Job creation

As shown in the table, each tiny unit registered under the Factories Act is said to employ 20 persons, on average; this would imply employment of 4 million people. About one third of the oil produced today is from this source. If all this oil were to be produced in the large sector (solvent extraction) 1,500 units would be required, and the employment generated would only be about 200,000 persons. A combination of expanded ghani facilities backed up with solvent extraction would extract all of the oil with the maximum spread of employment. In terms of capital utilization, ghani technology is three times as effective as large-scale technology.

CHARACTERISTICS OF THE THREE CATEGORIES OF VEGETABLE-OIL PRODUCING UNITS IN INDIA, 1974/75

	Category[a]			
Characteristic	*Tiny*	*Small-scale*	*Large-scale*	*All three*
Number of units	1 603	605	55	2 408
Number of employees	31 349	23 714	7 242	64 273
Gross output (Rs millions)	3 468	4 242	1 591	95 768
Capital-output ratio	0.41	0.57	1.25	0.60

Sources: Bimal Jalan, "Production in tiny, small- and large-scale sectors", *Economic and Political Weekly*, 20 May 1978, p. 853; *Annual Survey of Industries for 1975/1976* (New Delhi, Ministry of Industry).

Note: Only factories registered under the Factories Act are included.

[a] The units are categorized according to their fixed capital (land, buildings, plant and machinery at book value) as follows: Rs 100,000, tiny; between Rs 100,000 and Rs 1 million, small-scale; more than Rs 1 million, large-scale.

Power-expeller technology

Oil seeds such as ground-nut, rape and mustard, sesame, coconut, linseed, castor and safflower all carry sufficient oil to permit a recovery of 67–75 per cent by ghani technology. Newer oil sources such as cotton seed are lower in oil content (below 30 per cent after dehulling), and expellers that work at much lower pressures than ghanis are needed to obtain a fair yield of oil. Yet other new oil sources, such as soya, rice bran and oil-cakes, need solvent extraction to glean the oil present.

Expellers were adopted at a certain stage of development in the country since they were more efficient in extracting oil than ghanis, had higher throughputs, showed a good capital-output ratio and yielded fair employment levels. Where a conscious rural dispersal of low-capital industry is being sought, however, they would be less attractive than a combination of ghani extraction reinforced by solvent extraction.

Lack of good marketing is the chief drawback of small industry, which in consequence has been limited to markets within easy reach by foot or bicycle. This limitation can be overcome when groups of small oil manufacturers feed their raw oil to a common pool which is large enough and financially strong enough to afford the costs of good packaging and wide marketing, distribution and publicity. The other advantage is that, while small units have so far been able to market only raw oils, group marketing will permit common facilities for oil storage and processing to be set up; this will extend the range of products. Refined oils, hydrogenated fats, margarines and bakery fats could all be manufactured with capital borrowed from banks or generated from sales.

Such grouping can best be achieved through the formation of co-operatives operated by the ghani oil producers themselves. A good example of this kind of self-help is the dairy industry, which is run almost totally on the co-operative pattern. The best co-operative groupings will be apparent after the geographical distribution of the present oil mills has been established. At the moment, two villages in every five appear to have ghanis.

Marketing aspects

The use of raw oils is traditional; consumer demand has depended on the flavours characteristic of various fresh oils. Such preferences are strongly regional. Well-known examples are the insistence in Bengal on raw rape/mustard oil and in Kerala on raw coconut oil. There would probably be a considerable demand for unrefined oils in suitable packs, because oils sold from bulk containers are frequently adulterated, and brand-name packed products would carry a greater assurance of reliable quality.

Refining yields oils that are bland, colourless and odourless. The choice for the consumer then shifts from flavour to other characteristics such as appearance, frying behaviour, stability, unsaturation or health promotion. The cost of refining cannot be justified in nutritional terms; primarily it rests on cleanliness.

A serious constraint today is the cost of packing in tins. There is a good case for dispensing oils, whether raw or refined, through vending machines into the customer's own container. The success of milk vending in this way is pertinent. Oil vending would be less expensive than milk dispensing since refrigeration would not be necessary.

Appropriate technology for oils and fats in Yugoslavia

*J. Turinski**

Background

This paper describes the experience of Yugoslavia in applying appropriate technology to oils and fats. Although climatic and socio-economic conditions in other developing countries may differ from those of Yugoslavia, it could be of use to many of them.

Immediately after the Second World War, the oils and fats industry in Yugoslavia was scattered and uneconomic. It consisted of outdated small factories processing mainly rape, sunflower, mustard and sesame seeds, pumpkin kernels, ground-nuts, castor beans and olives. Yields were low, collection and transport were inefficient and storage capacity was inadequate.

This can be illustrated by the sunflower, the most important oil-seed material in Yugoslavia. In 1957, sunflowers were grown on 81,600 ha, with an average yield of 1,140 kg/ha and total production of 93,000 tonnes (t) of sunflower seed. Only 30,000 t of the oil-bearing material produced could be properly stored. In 1957, 68,000 t of refined oil were produced from various oil-bearing materials, along with 8,400 t of margarine and 3,300 t of vegetable fat.

During the next 20 years, the oils and fats industry developed larger capacities, increasing the assortment of products, both for the domestic market and for export, and raising productivity.

At present, the Yugoslav oils and fats industry consists of 14 medium and three large enterprises, with capacities ranging from 60 to 700 t/d. All the factories use mechanical expelling processes for oil extraction, and most of them use solvent-extraction processes also. Several refine crude oils; five factories produce vegetable fats, shortening and margarine.

The present production of these factories largely satisfies the growing domestic demand. Average annual *per capita* consumption in 1957 was only 2.6 kg of vegetable oils and fats, while in 1977 it was 10.6 kg of oil and 1.7 kg of margarine and vegetable fats. (The annual *per capita* consumption of animal fats is about 9.6 kg.)

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Supply of raw materials

Sunflower is the predominant oil-seed crop in Yugoslavia. In 1977, sunflower production in Yugoslavia was 468,290 t, a fourfold increase in 20 years. This expansion has been mainly due to intensive R and D efforts and application of modern technology in sunflower production. (Soya-bean and rape-seed production have also risen.)

Work was carried out in the selection and introduction of new sunflower varieties and the creation of new hybrids resistant to fungus diseases. Investigations were also made into the effects of regional climatic and soil conditions. Improvements were also made in the storage and processing of oil-seeds. The older domestic sunflower varieties contained about 30 per cent oil; Russian varieties introduced in 1961 contained up to 45 per cent oil.

By 1977, more than half of the total of 208,000 ha given over to the sunflower crops was with new hybrid varieties. The yields averaged 2,290 kg/ha, twice as high as in 1957. In certain areas, yields reached as high as 4,500 kg/ha. The production of oils per hectare increased not only because of the increase of seed yield but also because of the better varieties of seed used. In the period 1951–1960 the average yield of sunflower oil per hectare was 309 kg (domestic varieties); in the period 1961–1970 the yield averaged 796 kg of oil (Russian varieties) while in 1977 the yield of oil per hectare reached 1,000 kg. In 1978, the area under new hybrids rose to over 200,000 ha, and even higher yields were expected.

Storage of oil-seeds

Until about ten years ago oil-seeds were stored in simple rooms. The older sunflower varieties had thick hulls and low oil content and caused few problems. However, after the introduction of mechanical harvesting, and particularly of new varieties of sunflower seed with thinner hulls and higher oil and lineolic acid content, the problems of storage became more complex. Since the quantities produced were constantly increasing, storage and drying became more important.

Seed stored in damp conditions is subject to various negative effects such as:

Germination and spontaneous heating

Chemical and microbiological changes

Oil hydrolysis in sunflower seed

Increase of free fatty acids

Rotting, resulting eventually in the reduction of protein content

Danger of spontaneous combustion

These problems are likely to occur particularly in silos that lack adequate ventilation.

It has been found that the best solution is to build multipurpose stores, to include also rape-seed, barley, wheat, maize and soya beans. The condition of the seed to be stored is also important. Harvesting of the sunflower should start three to four days after it has reached its physiological maturity, with the moisture content not exceeding 14 per cent. Observing these conditions has been found helpful in preserving the collected seed.

Better use of oil-bearing raw materials

Application of appropriate technology also assumes a better use of primary agricultural raw materials. It should also solve any problems with secondary raw materials.

Ripe sunflower seed contains approximately 45 to 47 per cent oil, 25 per cent hulls and 14 per cent protein. The rest is usually moisture.

Sunflower oil is of high value being a mixture of triglycerides of various fatty acids, mainly highly unsaturated, essential and unsaturated fatty acids, which have positive biological effects in the human body.

Sunflower seed provides high-quality salad and cooking oils, as well as other final products (margarine with polyunsaturated fatty acids, mayonnaise, salad dressing and the like). It is very stable and can endure long periods of storage and transport in a wide range of climatic conditions, compared to most other liquid oils such as soya-bean and rape-seed oils. It is also used for deep frying with good results.

Sunflower proteins are used for cattle feed and as supplements to human foods. The traditional method of using sunflower meal with 33–34 per cent of protein for feeding domestic animals proved uneconomic. It was replaced by sunflower meal containing 44 per cent protein by using the hulls-separation process.

Further research was started into industrial production of protein flour from sunflower meal with 55 to 60 per cent proteins, concentrate with 65 to 70 per cent protein and isolate with 90 per cent protein. Encouraging results were obtained both in the laboratory and in pilot plants. Sunflower protein flour can be used for human consumption as well as for feeding calves, as a substitute for natural milk.

A certain amount of sunflower-seed hulls (6 to 8 per cent) remains in the meal and is used as animal feed. Better use of hulls implies the application of microbiological and chemical processes in the production of feeds, waste products and single-cell proteins. Some research work is already under way.

The hulls are used widely as a construction material (thermo-isolation plates) as well as a medium-calorie fuel. One kilogram of sunflower hulls (containing wax and oil) can provide about 4,000 kcal (16 MJ). An industrial plant with a processing capacity of 600 t/d of sunflower seed provides, through decortication about 100 t/d of sunflower seed hulls, consuming about 6.5 t of steam per hour. The hulls thus obtained can produce, in a suitable vertical boiler, 25 t of steam, enough to supply the same factory.

Selection of appropriate technology

The selection and application of the appropriate technology for the industrial production of oils and fats is a dynamic process. At the beginning the process was rather traditional. However, the application of appropriate technology does not always imply old and outdated (classical) solutions. At this stage of development, the industry must ensure better utilization of oil-seeds as well as higher-quality production. In this respect, for some countries and under certain conditions, the use of the more sophisticated technologies can be recommended. Some examples are continuous solvent extraction and continuous and semi-continuous refining. For the better utilization of palm fruit, it may be advisable to install up-to-date plants for refining (with the removal of *beta*-carotene), fractional crystallization, interesterification and hydrogenation of palm-kernel oil so as to produce hard butters for confectionery and as a substitute for cocoa butter in confectionery and candy.

In a number of cases, in particular in less-developed countries, small-capacity multipurpose plants with daily processing capacities of 60 t of oil-seeds are recommended. There are various reasons for applying a simple technology and corresponding equipment. In fact, many developing countries have small and scattered productions of oil-bearing materials. In addition, various oil-bearing materials have to be processed in the same plant. The transportation network is often undeveloped and unfit for long-distance transport. In these conditions, multipurpose and functional plants might be more suitable; that is, plants with smaller capacities that can be fully utilized, quickly constructed, easily operated and maintained and provide a faster turnover of invested capital. In the course of further development, these factories could become nuclei and stimuli for gradual specialization of producers, as well as encouraging interest in the most suitable oil-seeds. In any case, the appropriate technology for producing oils and fats should not be based on only one oil-seed raw material. Even with large and more sophisticated units, it should imply certain alternatives and flexibility.

Co-operation with the domestic machine-construction industry

In an effort to ensure more stable expansion of its capacities and normal operation and maintenance, the oils and fats industry in Yugoslavia has closely co-operated with factories making equipment and spare parts. This co-operation is especially evident in the following:

(a) Programming, planning and implementation of adopted development programmes of the oils and fats industry in the construction of new and expansion of existing capacities;

(b) Designing capacities and plants for production of oils and fats;

(c) Designing machines and electrical equipment;

(d) Establishing, constructing and improving power plants, required infrastructure (paths, roads and railways), storage and related capacities.

This co-operation has helped to develop a co-ordinated approach to the acquisition of foreign technology, equipment and finance for the technological development of the country.

This has also stimulated co-operation in the Yugoslav engineering and electrical machinery industries, in the acquisition of technology, know-how, technical and other assistance, as well as establishing business co-operation with other countries, particularly developing ones.

There are numerous examples of industrial co-operation with one or more foreign equipment manufacturers in various civil engineering projects. These include storage facilities (concrete or steel silos, with complete facilities for discharge, cleaning, drying, ventilation, cooling and transportation of sunflower seeds, soya-beans and the like; production of processing equipment; individual and complete technological lines (for preparation of oil-seeds, for cleaning and decortication, and further processing of sunflower seed, as well as the construction of related plants, such as boiler plants for hull breaking, compressor stations and cooling equipment).

Staff training

In Yugoslavia, the quality of management and technical staff has been found to be the key to industrial progress. It is considered valuable to train staff in further industrial development and professionally oriented studies.

In the oils and fats industry, and in sunflower production and processing in particular, Yugoslavia has made significant progress, supporting the wider exchange of experience, transfer of technology, know-how and scientific information. Various group training programmes for engineers in agro-industrial enterprises have been organized in co-operation with UNIDO. Programmes of training have been carried out bilaterally with a number of developing countries.

Annex I

SELECTED DOCUMENTATION PUBLISHED OR COMPILED BY UNIDO RELATING TO THE SUBJECT

Castor oil production and processing. New York, UN, 1974. 23 p. (ID/125)
Also published in French and Spanish.
Sales no.: 74.II.B.11.

Guidelines for the establishment and operation of vegetable oil factories. New York, UN, 1977. 116 p. tables, diagrams, illus. (ID/196)
Also published in Spanish.
Sales no.: 77.II.B.1.

Information sources on the vegetable oil processing industry. UNIDO guides to information sources no. 7. rev. ed. 1977. 98 p. (ID/197)

Information sources on the soap and detergent industry. UNIDO guides to information sources no. 24. 69 p. (ID/181)

Technical and economic aspects of the oil palm processing industry. New York, UN, 1974. 40 p. tables, figures. (ID/123)
Also published in French and Spanish.
Sales no.: 74.II.B.10.

The hydrogenation of vegetable oils and production of vegetable ghee. New York, UN, 1974. 40 p. illus. (ID/124)
Also published in French and Spanish.
Sales no.: 74.II.B.7.

Pre-investment considerations and appropriate industrial planning in the vegetable oil industry. New York, UN, 1974. 32 p. (ID/122)
Also published in French and Spanish.
Sales no.: 74.II.B.6.

Review and comparative analysis of oilseed raw materials and processes suitable for the production of protein products for human consumption. New York, UN, 1974. 36 p. tables, figures. (ID/126)
Also published in French and Spanish.
Sales no.: 74.II.B.8.

A case study on the establishment of export-oriented oil-seed processing industries in developing countries. 1978. 23 p. tables, diagrams. (UNIDO/IOD.169)

A study on vegetable fats and oils and animal feed industry in the Syrian Arab Republic. Prepared by A. Sheikh Al-Kar for the Regional Meeting on the Development of Selected Branches of the Food Industry in Selected Countries of the Middle East, Beirut, Lebanon, 1975. 1975. 43 p. tables. (ID/WG.201/7)

Country report on fats and oils in Iraq. Paper prepared by T. Babushap for the Regional Meeting on the Development of Selected Branches of the Food Industry in Selected Countries of the Middle East, Beirut, Lebanon, 1975. 1975. 18 p. tables. (ID/WG.201/10)

Draft recommendations. Regional Meeting on the Development of Selected Branches of the Food Industry in Selected Countries of the Middle East, Beirut, Lebanon, 1975. 1975. 77 p. tables. (ID/WG.201/14)

Draft world-wide study of the vegetable oils and fats industry: 1975–2000. 1977. 177 p. tables. (UNIDO/ICIS.46)

Industrial performance evaluation profiles standard questionnaire for the vegetable oil industry (with explanatory notes). 1974. 155 p. tables, diagrams, flow charts. (UNIDO/IPPD.149)

Project for the establishment of a vegetable oil hydrogenation plant. Corporación Boliviana de Fomento. 1978. 51 p. tables, diagrams, graph. (UNIDO/IOD.217)

Report of the First Consultation Meeting on the Vegetable Oils and Fats Industry, Madrid, Spain, December 1977. 1977. 17 p. (ID/WG.260/9)

Also published in French, Russian and Spanish.

Report of the Regional Preparatory Meeting for Consultations on Agro-Based Industries: Oils and Fats Industry. Consultation Meeting on the Vegetable Oils and Fats Industry, Madrid, Spain, 1977, jointly organized by ESCAP and UNIDO. 1977. 24 p. tables. (ID/WG.260/1)

Report of the Regional Preparatory Meeting for Consultations on Agro-Based Industries: Vegetable Oils and Fats Industry. Consultation Meeting on the Vegetable Oils and Fats Industry, Madrid, Spain, 1977. 1977. 7 p. (ID/WG.260/3)

Report on UNIDO/OTAI Co-operation Programme for Vegetable Oil Technicians and Technologists from Developing Countries. 1977. 16 p. (UNIDO/IOD.61)

Research and development of a small-scale, low-cost rice bran stabilizing unit. Report of the *Ad hoc* Expert Group Meeting, Vienna, Austria, 1976. 1977. 20 p. diagrams. (ID/WG.240/10)

Rice bran stabilization. Paper prepared by D. Adair for the *Ad hoc* Expert Group Meeting on the Research and Development of a Small-Scale Low-Cost Rice Bran Stabilization Unit, Vienna, Austria, 1976. 1977. 10 p. (ID/WG.240/5)

Small capacity rice bran oil extraction plants. 1978. 8 p. (UNIDO/IOD.227)

Socio-economic aspects of rice bran stabilization in rice producing countries. Paper prepared by M. El-Mallah for the *Ad hoc* Expert Group Meeting on the Research and Development of a Small-Scale, Low-Cost Rice Bran Stabilization Unit, Vienna, Austria, 1976. 1977. 5 p. (ID/WG.240/6)

Stabilization of rice bran. Paper prepared by S. Barber for the *Ad hoc* Expert Group Meeting on the Research and Development of a Small-Scale, Low-Cost Rice Bran Stabilization Unit, Vienna, Austria, 1976. 1977. 14 p. graphs, tables. (ID/WG.240/7)

Summary of the draft world-wide study of the vegetable oils and fats industry. 1977. 47 p. tables. (UNIDO/ICIS.47)

Technologies from developing countries. Development and transfer of technology series no. 7. 1978. 35 p. (ID/208)

Menthol from mint oil, p. 3.

Technologies from developing countries. International Forum on Appropriate Industrial Technology, New Delhi and Anand, India, 1978. 1978. 251 p. (ID/WG.282/65)

Ethyl ether, p. 17.

Production of weaning food, p. 107.

Machine for decortication of sesame seed, p. 127.

Fat liquors for leather processing, p. 144.

Silicone oils production, p. 145.

Synthetic pine oil from turpentine, p. 146.

Integrated processing of sesame seed, p. 147.

Oil from shark liver, p. 148.

Substitution of diesel oil by vegetable oils, p. 149.

Portable essential oil distillation unit, pp. 150–151. diagram.

Vegetable oils and fats and animal feed industries in Lebanon. Paper prepared by R. Tannous for the Regional Meeting on the Development of Selected Branches of the Food Industry in Selected Countries of the Middle East, Beirut, Lebanon, 1975. 1974. 9 p. tables. (ID/WG.201/2)

Technical information compiled by the Industrial Inquiry Service (IIS) and the Industrial and Technological Information Bank (INTIB)

Copies of these compilations are available to requestors from developing countries only. The reference number must be quoted.

Castor oil. (IIS file no. x6112–15)

Mint oil. (IIS file no. x3653–55)

Oil from spices. (IIS file no. x3816)

Palm oil. (IIS file no. 6597)

Soap making plant. (IIS file no. 5862)

Annex II

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