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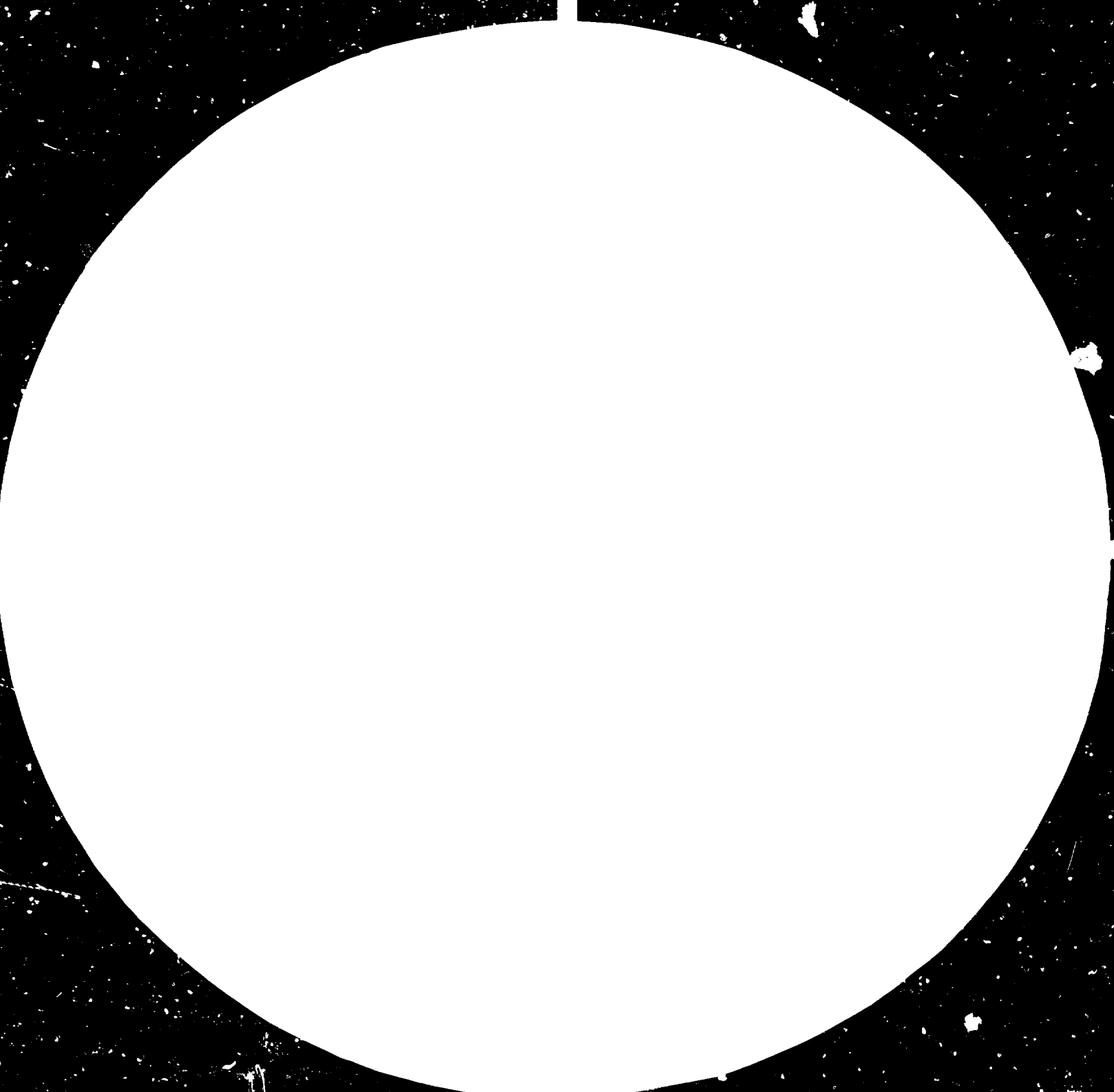
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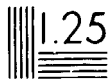
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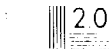
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12375

Distr.
LIMITED

UNIDO/IO.537
23 March 1983

UNITED NATIONS
INDUSTRIAL DEVELOPMENT ORGANIZATION

ENGLISH

THE VEGETABLE OIL INDUSTRIES DEVELOPMENT SECTOR*

A review of policies and approaches to
appropriate vegetable oil industrialization

This document was prepared by the UNIDO secretariat for the Meeting on the Promotion of Co-operation Among Developing Countries in the Development of Food Processing Industries organized by UNIDO on the occasion of the 50th International Fair, Novi Sad, Yugoslavia

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Introduction

The climatic and soil conditions of most of the developing countries and the availability of suitable land allow and even favour the production of high-yielding oilseeds and oilfruits, which form a potential natural raw-material basis for the establishment of profitable oilseed processing industries for the production of high-quality edible and technical vegetable oils and of oilseed protein food and feed products for local consumption and export.

The oilseed processing industry is a fundamental agro-industry that provides the basis for a variety of related industries that use crude vegetable oil to produce refined oils, hydrogenated oil products, margarine, fatty acids, soaps and fatty-acid-based detergents. Oil-cake, extracted meal, mixed feed and feedstuff concentrates, the availability of which is a pre-condition for modern livestock development and, not least in importance, the production of oilseed protein food products from extracted meal receive steadily increasing attention. The existence of an efficient vegetable oil industry is, therefore, the starting-point for the establishment of a chain of related and economically linked industries. It can be the nucleus of an appropriate industrialization and a good investment opportunity on the solid basis of a steadily increasing market demand for most oilseed products, and existing raw-material potential and well-known and advanced processing technology and industrial know-how. UNIDO is, therefore, paying particular attention to the industrialization of oilseed processing in developing countries.

Many developing countries possess abundant but not yet utilized oilseed raw material resources, the industrial exploitation of which poses countless problems. Among these are unfavourable infrastructures, the lack of transport and appropriate storage facilities, unsuitable methods of collection or harvesting and preparation and, of great importance, financial matters, all of which require careful pre-investment

evaluation and thorough industrial planning. In order to solve such problems and to secure adequate supplies of raw material for the oilseed processing industries sector, close co-operation among developing countries is required. Views, experience and information must be exchanged on all issues of industrial oilseed processing, and the conclusion of trade agreements, joint venture and other forms of co-operation must be considered seriously. However, not only must there be appropriate use of raw materials that are now unutilized; there must also be the adoption of suitable modern processing methods in existing factories if these developing countries are to achieve an optimum degree of industrial efficiency.

In presenting this paper an attempt is made by UNIDO to draw attention to the basic principles of appropriate industrial oil milling operations. Policy considerations are outlined, relevant approaches to avoiding problems and/or solving them are discussed and illustrated and broad guidelines are given for the consideration of those involved or willing to get involved in industrial oilseed processing activities.

I. Policy considerations

The production of edible oils from various oilseeds has for centuries been a rather important human activity. In the past, high yielding oilseeds such as sesame and groundnuts and fruits such as olives were crushed and pressed to extract their edible oils, using simple methods and unsophisticated equipment. Even today oilseed crushing is done in artisan ways in some developing countries.

In more recent years, oilseed production has become an organized agricultural activity with a world market, with the result that oilseed processing activities have risen from the artisan and small scale level to an industry of increasing importance. Processing methods and technologies have progressed together with these developments, in turn creating new products and markets.

The rapid technical and economic developments of recent years have led to the establishment in predominantly industrially developed countries of large scale modern oilseed processing industries that have far out distanced those of most of the developing countries, despite the fact that these countries produce the bulk of the world's oilseed raw materials. The present situation in the developing countries is quite complicated, appropriate oilseed processing industrialization very often necessitates for reaching policy decisions and fundamental techno-economic re-organization.

I/1 The market-oriented approach

Attention may be drawn to the fact that the entire world population is in need of oilseed products such as edible and technical vegetable oils, protein food and feed products, fatty acids and soaps. Large scale oilseed processing factories have been set up and are operating successfully in countries with very little oilseed potential or even none at all. Therefore, it cannot be only the availability of oilseed raw materials that justifies the establishment of such industries, other and more important criteria must be considered.

Many experts, institutes and organizations concerned with the industrial development of developing countries still regard the local availability of raw materials as the prerequisite for the establishment of an industry. Indeed, UNIDO is very often told that industrialization must be considered as dependent upon an expanding production of agricultural raw materials.

In point of fact, however, agricultural raw materials from developing countries, which are very often grown on small-scale holdings or by co-operatives, are seldom suitable for industrial processing. Experience has taught that these raw materials are unsuitable for industrial processing with respect to their quality, quantity, variety, price and time of delivery. They are traditionally and primarily destined for individual village scale consumption or use, but a modern processing industry, requires raw material that is adapted to its technical and commercial specifications and which can only very seldom be met by the conventional producers of raw materials. Should this situation lead to the conclusion that industrialization is hence not feasible?

It has often been proved that raw material supplies are no longer the primary economic and technological starting point for the establishment of an industry. Their significance has been negated by the need for a detailed and comprehensive analysis of the potential market to ascertain precisely the type, variety, quality, quantity and selling price of the products demanded. The next step is the decision as to the type and size of plants required to produce the products shown to be in demand by the market study. Then, and only then, does the question of raw-material availability arise. It may well transpire that, for an initial period at least, imports of raw material are not only unavoidable but even profitable. In any case, they are more profitable in the long run than imports of finished goods. Such an approach may not necessarily involve foreign exchange problems if suitable agreements are entered into among the developing countries of a region, thereby creating a most desirable regional co-operation.

The policy considerations given above are unquestionably equally valid for countries that do possess oilseed raw-material potentials. In this situation, industrial production should be market oriented from the outset, and the availability of ample supplies of raw materials is a very favourable additional factor. A precondition for the optimum utilization of raw materials in a modern processing industry is an existing market demand for its products.

I/2 Industrial combines

The oilseed processing industry is one of the fundamental agro-industries (see Introduction) upon the product of which a chain of related processing industries can be elaborated. Some links in this chain are the edible-oil refining industry, hydrogenation, margarine and vegetable ghee production, fatty-acids, soap and detergent production and, not least in importance, the production of oilseed protein food and feed products.

When considering the establishment of an oilseed processing industry, the utilization of its various products in follow-up industries should be given due attention within the framework of an appropriate industrial development programme.

When discussing industrial programming in the oilseed processing industries sector, attention should be drawn to the usually most efficient type of modern industrial structure, namely the industrial combine or industrial complex. This form of industrial organization combines a number of different production units under one general management, and each unit is designed for the further processing of the products of another one that is before it in the chain.

It is evident that, because of reduced transport and storage charges and minimized overhead costs, great production flexibility and other very favourable economic production criteria, the industrial production efficiency of such industrial combines is very much higher than that of a number of individual production units that are isolated from each other organizationally, economically and physically.

I/3 Integrated industries

A modern market-oriented industry will never be efficient and viable if it fails to secure a steady supply of raw materials in sufficient quantity and of suitably quality. It has often been found that

technically efficient oilseed-processing plants in developing countries have had to produce below capacity and have even been taken out of production for shorter or longer periods because of the unavailability of raw materials. Despite their technical efficiency, such factories always suffer considerable financial losses, and their decreasing industrial productive efficiency seriously impairs their competitive position.

As early as the pre-investment stage, the raw material supply of a projected factory must, therefore, be studied thoroughly in order to avoid foreseeable difficulties. The raw material supplies of the oilseed-processing industries of developing countries can best be assured by the establishment of integrated industries, meaning the integration of raw-material production and processing under one general management. This particular approach has been practised very successfully, for example, in both the palm-oil and sugar industries. Consequently, the establishment of such integrated industries in the oilseed processing sector of developing countries would be a great step forward towards modern industrialization.

II The oilseed product market

The oilseed processing industry necessarily has to produce two different products, namely the vegetable oil and the protein meal/cake. It is often wrongly taken for granted that the main product is the oil and the by-product is the meal or cake. One should be aware of the fact that both products are main products that have to be effectively marketed in order to maintain an economically efficient industrial production. This situation results in the fact that an oilseed processing industry has to enter two different markets with its products. The two markets follow independent rules and hardly any relation exists between them.

There are very few exemptions to the "two market situation", namely only those industries that process oil bearing raw materials with no protein residue component. This is in the first instance the palmoil industry. It is not difficult to realize that a large supply of oil that is not connected with a relevant supply of protein meal has to affect the market supply balance of the two products in favour of the oil. This fact has some bearing on the vegetable oil industry in general and makes valid market evaluations as the basic for the setting-up and operation of vegetable oil industries more difficult or - depending on the prevailing standpoint - more easy.

The vegetable oil industry as a basic agro-industry necessarily stimulates to a great extent the agriculture as it provides the market for agricultural raw materials (oilseeds). But it also stimulates the setting-up of related industries that again provide the market for its products. In this connexion the strong links have to be pointed out that exist between the vegetable oil industry and the animal feed industry a very important raw material component of which are protein cakes and extracted meal.

In the developed countries the per capita consumption level of 20 to 25 kg per year is already very high. A further increase of the per capita income will hardly lead to a substantial increase in consumption of oils and fats. It can safely be assumed that the markets of the developed countries in general is very close to saturation.

In the developing countries the upward change of the per capita consumption of oils and fats in line with the population growth is a powerful determinant of an increasing demand for vegetable oils and fats. In many developing countries the level of effective demand for fats and oils is rising faster than the rate of domestic supplies.

While there is no question about the high and steadily increasing market demand for vegetable oils in developing countries, the specific individual demand of a country, however, is more difficult to assess and requires a case by case investigation. Traditional eating habits play an important role, the climatic conditions and also the packaging and distribution requirements.

When investigating a market one should be aware of the fact that with the aid of modern technology, nearly all vegetable oils are substitutable to a very high degree both with each other and also with animal fats and marine oils. The consumer and the manufacturer of food products using vegetable oil normally has a wide choice and will, therefore, choose the readily available product with the most reasonable price.

A new set of variables comes into play when considering the markets for oil cakes and protein meal. Substitution, although possible, is constrained by the nutritional requirements of the feedstuff industry. The demand for cakes/meal is, therefore, dependent on the demand for livestock production and finally meat consumption.

In the developed countries, the oilseed protein feed market still has an increasing tendency but is characterized by an extreme sensitivity with regard to quality and price. Exports of oilseed protein to the developed countries have to compete with soyabean meal which is predominantly produced in developed countries and which still is the market price indicator.

In the developing countries hardly any large scale animal feed industry exists. However, measures have been taken in most of them to improve the livestock production sector which necessitates the industrial production of mixed compounded animal feed. As a first step the poultry farming sector is rapidly increasing which goes along with an increased demand of animal feed and subsequently oilseed protein meal.

In conclusion it needs to be pointed out that a vegetable oil industry to be set up or in operation in developing countries will have to very carefully consider exports to developed countries prior to entering the very competitive international hard currency market. An industry will have to be especially designed to meet these requirements. However, there is a very good opportunity for exports from one developing country to another in case special agreements can be entered into that form the basis for mutual trade benefits. All developing countries with a vegetable oil industry potential and interested in exports of vegetable oils and fats as well as oilseed protein products should, therefore, be encouraged to conclude relevant co-operation agreements among themselves in order to create the basis for modern vegetable oil industrialization based on mutually beneficial international trade.

III The vegetable oil industry

An oilseed processing factory, like all continuous operations, naturally follows the principles of an upward economy of scale. The production capacity of an industrial plant should, therefore, be as large as feasible based on modern processing technologies, up-to-date equipment and efficient management.

The traditional oil milling operations of many developing countries are characterized by single mechanical pressing units. Such factories may well be efficient from an entrepreneurial point of view if they are in line with the prevailing raw material supply and product market situation. From the national economic view point, however, one should be aware of the fact that considerable quantities of oil are lost because of the oil cakes having a residual oil content of between 7 and 10 per cent. The residual oil in the cakes may sometimes be advantageous in animal feed formulations, the fat requirements of which, however, are normally much lower than normally assumed.

The more efficient way of oil milling, however, is solvent extraction or a combination of pre-pressing and solvent extraction. The residual oil content of the meal is below one per cent and the energy requirements are by far lower than in mechanical processing units. Solvent extraction plants, however, are normally larger scale operations and hardly suitable for operation in areas with insufficient infrastructures.

The location of an oilseed processing factory plays a very important role as it has considerable impact on the transport and storage costs of either raw materials or products. Raw material transport costs are often higher than product transport costs as the volume and weight of hulls and shells is still included. Oil milling operations located in suitably developed rural oilseed growing areas may, therefore, be advantageous particularly if the oil cakes or extracted meal produced can find local use in relevant animal feed factory operating in the same area - An export industry, however, will more beneficially be located in urban areas with easy access to loading and unloading facilities at harbours, railway or truck stations despite the perhaps higher raw material transport costs involved.

In any case a vital element in the operation of an oilseed processing plant is the secured supply of raw materials which should permit the factory to operate twenty-four hours a day and minimum 250 to 300 day per year. The required raw material has, therefore, to be processed by relevant supply contracts with suitable supplier organizations.

Assuming that an oilseed processing factory has a daily throughput capacity of 100 tons of oilseeds, which is rather small size solvent extraction plant, the required storage capacity will have to be 3000 tons for only one month. Industrialists should, therefore, be aware of the storage costs involved.

A disadvantage of an oilseed processing plant is the very limited turnover with normally only one to five a year depending on the purchasing contracts compared with an oil refinery or margarine factory with twenty or more possible turnovers.

IV The processing technology

Any vegetable oil factory should be designed to produce quality products with a cost minimum. It is, therefore, essential that the most suitable processing technology is to be applied by having it tailored to its specific requirements. It is normally only a standard technology that is available from relevant equipment producers. Such standard equipment, however, does not normally take care of the particular requirements of special individual oilseed raw material processing operations unless they are clearly specified.

It would exceed the scope of this paper to discuss the specifics of the technology suitable for each type of oilseed raw material and it is, therefore, necessary to limit the discussions to two types of oilseeds, namely those with a low oil content and those with a high oil content and generally elaborate on processing methods. The figures in paranthesis refer to the assumed lay-out plant for a vegetable oil factory attached as Annex 1.

V The factory operations

All oilseeds have to be carefully weighed and registered when entering the factory and prior to storage. The installation of automatic weighing and registration machines are, therefore, essential (2). Samples are to be taken from each lot of raw material that arrives in the factory in order to be analysed at the factory's own quality control laboratory with regard to moisture content, oil content, impurities, percentage of shells/hulls and probably protein content.

The raw material storage should specifically be designed for the type of seed to be stored (3). Bulk storage should be given preference over bag-storage. The store-houses are to be well ventilated in order to prevent self-ignition. The store house should be equipped with mechanical unloading, internal transport and feeding devices.

From the store house, the seed is transported to the preparation unit (15) where it is cleaned from impurities, delinted and dehulled if applicable (cottonseed, sunflower seed, etc.) and by passing certain cutting/milling equipment (breakers, fluted rollers, disc mills, etc.) the seed is broken into small pieces. The linters and shells are transported to a special store house (19) (20) and should in the absence of other means of utilization be used as boiler fuel. The steam boiler (22) should in this context be specifically designed for this purpose. Hulls are not normally sufficient to produce the required steam and provisions should be made for mineral oil fueling as well. A fuel oil tank needs to be installed next to the boiler (21).

Two possible ways of processing are now open depending on the type of seed, namely direct solvent extraction or pre-pressing and solvent extraction. Oil seeds with a low oil content such as soyabean (18 per cent) or probably cottonseed (30 per cent) may be solvent extracted without pre-pressing. Oilseeds with a higher oil content, as for example ground nuts, sunflower, etc. are normally pre-pressed in order to produce vegetable oil and oil cakes with a residual oil content of approximately 15 to 18 per cent. The pre-pressed oil cakes are then solvent extracted where again vegetable oil is obtained and the extracted protein meal with a residual oil content of less than one percent. Low yielding oilseeds that require direct solvent extraction normally pass flaking rolls that produce flakes of approximately 0,1 - 0,05 mm thickness.

After appropriate preparation, high yielding oilseeds enter the prepressing unit (6). The seed is heated and softened in special conditioning devices prior to entering the pre-presses. Modern pre-presses are large capacity machines (50 tons/24 hours and more) that work continuously. The electricity consumption per ton of seed and the wear and tear aspects unfavourably effecting the final pressing technology are reduced to a minimum in modern pre-presses that operate with comparatively low pressure. Crude vegetable oil is produced and pre-pressed cakes with a residual oil content of approximately 15 to 18 per cent.

Either prepressed cakes or flaked decorticated oil seeds now enter the solvent extraction plant (7).

The solvent extraction technology, in principle, is based on the solvent(hexane)dissolving and extracting the oil contained in the seeds or pre-pressed cakes. The oil/hexane solution resulting therefrom is called "miscella", the concentration of which is normally between ten to thirty per cent oil in hexane. The miscella passes a series of vacuum distillation and condensation equipment where the hexane is being removed from the oil and recycled to the process. The hexane-wet meal leaving the extractor passes the desolventizer where it is made hexane-dry. The removed hexane is again recycled to the extraction presses. The extracted meal is dried and cooled and - if required pelleted - and stored in an especially designed meal storehouse (10) with relevant bagging and weighing equipment. The hexane-free oil is stored in tanks (11) and sold as such. Or - if required - the crude oil is sent to the vegetable oil refining plant (13) for the production of edible oil. Hexane as a solvent belongs to the inflammable products and is liable to special safety measures and instructions according to international law. Extremely careful handling of hexane is essential.

A modern vegetable oil factory has to be supplemented by its own laboratory (16) with round-the-clock operations a suitably equipped mechanical and electrical work shop with spare-parts stores (23), a special security office (18) with a security engineer in charge of solvent operations and last but not least an office building (17) that houses the management and the buying, selling and accounting department.

As mentioned before, a vegetable oil factory - for flexibility reasons may also operate a vegetable oil refining plant (13). Under the term "refining" four processes are normally understood, namely a) degumming, b) neutralization, c) bleaching and d) deodourization. All of the four processes can be made continuous. It might, however, be advisable to continuously carry out the neutralization and deodourization process while bleaching and degumming remain batch operations. Fully continuously operating refining plants should be based on only one type of raw material (crude vegetable oil) that is available in sufficiently large quantities and uniform quality.

The refined oil is preferably filled in bottles or cans that after appropriate sealing are sorted and packed in a special storehouse (13) ready for sales.

VI The technology and the capacity

The determinant capacity factor of an industrial vegetable oil factory is the solvent extraction plant. From the technical view point and considering the economy of scale, the minimum capacity of a solvent extraction plant should not normally be lower than 100 tons/24 hours of prepared extraction raw material. Normally, the higher the capacity, the better the production economy. In order to illustrate the relationship between the solvent extraction capacity and the total capacity of a vegetable oil factory, attention is drawn to the three cottonseed processing flow diagrams attached as Annex 2, 3 and 4.

A cottonseed processing factory with a total throughput capacity of 100 tons/24 hours of undelinted, undecorticated cottonseed with an oil content of twenty per cent will approximately produce the following products and by-products in 24 hours following the pre-pressing and solvent extraction process:

- a) 9,0 tons of linters;
- b) 31.0 tons of hulls;
- c) 19.9 tons of crude vegetable oil;
- d) 46,1 tons of extracted meal (0,5 % residual oil).

The factory will have to consist of the following processing capacities.

- a) delinting unit: 100 tons of cottonseed/24 hours;
- b) dehulling unit: 91 tons of delinted seed/24 hours;
- c) pre-pressing unit: 66 tons of dehulled seed/24 hours;
- d) solvent extraction unit: 54,8 tons of pre-pressed cakes/24 hours.

The unit throughput capacities and the products produced by the mechanical pressing process and by the direct extraction technology can be seen from the flow diagrams attached as Annex 3 and Annex 4.

VII The investment

An investor has normally to choose between two ways of establishing a factory, namely the turn-key approach and the individual approach.

The turn-key approach means that the investor is contracting the equipment manufacture, supply, installation and the trial operation of the complete factory with one and the same engineering company. The contractor takes over the full responsibility for the entire work to be carried out and is expected to hand over to the owner the complete factory ready for commercial operation. The turn-key approach is the more effective way of work, but is also the more expensive method. One will have to honour the responsibility and co-ordination work involved.

The individual approach involves a number of different suppliers, each of them only in charge of specific plant units or parts of them. One suitably qualified co-ordinator has to be appointed who is to be charged with the overall responsibility and who plays a vital role in the manifold activities involved in the establishment of an industrial plant. The costs involved are less but the risks taken are decidedly greater.

The actual investment costs can only be meaningfully estimated on the basis of a defined industrialization scheme. The type(s) of oilseed raw material has to be determined, the type(s) and quality of products to be produced, the detailed technology to be applied and the production capacity. It is nearly impossible to indicate costs of investment without prior definition of the one particular plant that is to be set up. As it was mentioned before, each factory is to be tailored to specific requirements.

VIII Man-power requirements and training

A vegetable oil factory should not be considered for establishment for employment reasons. It is not the type of industry that gives a good employment opportunity because of its rather high degree of essential mechanization. Preference is to be attached to a limited number of skilled workers that are to be made in charge of the mostly continuous, mechanized production process. The training element, therefore, plays a rather important role and both in-plant training and theoretic training courses should be arranged for well in advance of the new factory's commercial production.

Apart from the actual labour requirements at the vegetable oil factory no doubts exist about the very favourable influence the vegetable oil industry has on a country's overall employment situation. The indirect employment created by it is considerable when one considers the raw material production sector, the transport sector, the

product distribution and trade sector, and last but not least, the overall import and export sector with all the administrative and office work involved.

IX Aims and objectives of UNIDO assistance to developing countries in the vegetable oil industries sector

UNIDO activities in the oilseed processing industries sector are focused on the development and/or establishment of such industries in developing countries as suppliers of the various oilseed products in demand in domestic and export markets, as a stimulator and regulator of oilseed raw material production activities and as an important development factor for national economies and the overall industrialization process. UNIDO assistance is, therefore, guided by the following objectives.

- a) the optimum utilization of oilseed raw materials in viable processing industries and revalidation of by-products and residues;
- b) the re-structuring, modernization and techno-economic up-dating of existing vegetable oil industries;
- c) the establishment of viable new vegetable oil industries with due consideration of the additional investment opportunities inherent in them;
- d) the stimulation and implementation of pre-investment studies and appropriate industrial planning in the vegetable oil and related industries sector.

UNIDO activities in the oilseed processing industries development sector began in 1969. Since then some 200 operational field projects have been implemented in many developing countries inclusive process and product research and development work. To accomplish its task in this particular industrial development sector UNIDO - in line with its aims and objectives - performs the following activities in developing countries subject to funds available and based on an official request for assistance received from the relevant Government authorities.

For the optimum utilization of oilseed raw materials in viable processing industries and re-valuation of by-products and wastes:

- a) Introduction and application of suitable collecting, preparation transport and storage methods for oilseed raw materials destined for industrial processing, and assistance in the utilization of as yet unutilized oilseed raw materials;
- b) Introduction and application of the most suitable processing technologies for the various oilseeds and optimum utilization of by-products and reclamation of wastes;
- c) Assistance in the introduction and appropriate application of quantity and quality control methods for raw materials and their products.

For restructuring modernization and techno-economic updating of existing oilseed processing industries:

- a) Assistance in re-structuring existing but outdated production units, introduction of modern plant organization and management methods, and training of local staff;
- b) Assistance in the improvement of the processing technology in existing factories, the selection of suitable replacement equipment, and the organization of suitable maintenance and repair units, including spare-part production;
- c) Assistance in the improvement of technical and economic production efficiency in existing factories, including trouble-shooting operations.

For the establishment of newly viable oilseed-processing industries and relevant investment considerations:

- a) Preparation of industrial feasibility studies and assistance with consideration of technical, economic and financial pre-investment problems;
- b) Elaboration of technical project layouts, assistance in the preparation of tender documents and evaluation of quotations received on this basis from international equipment producers;
- c) Assistance in the construction of new oilseed processing factories, co-ordination of imported machinery with locally manufactured equipment and supervision of guarantee test runs;
- d) Assistance in the technical and commercial operations of new oilseed-processing plants.

For the adaptation of market-oriented industrial oilseed processing policies and appropriate industrial planning:

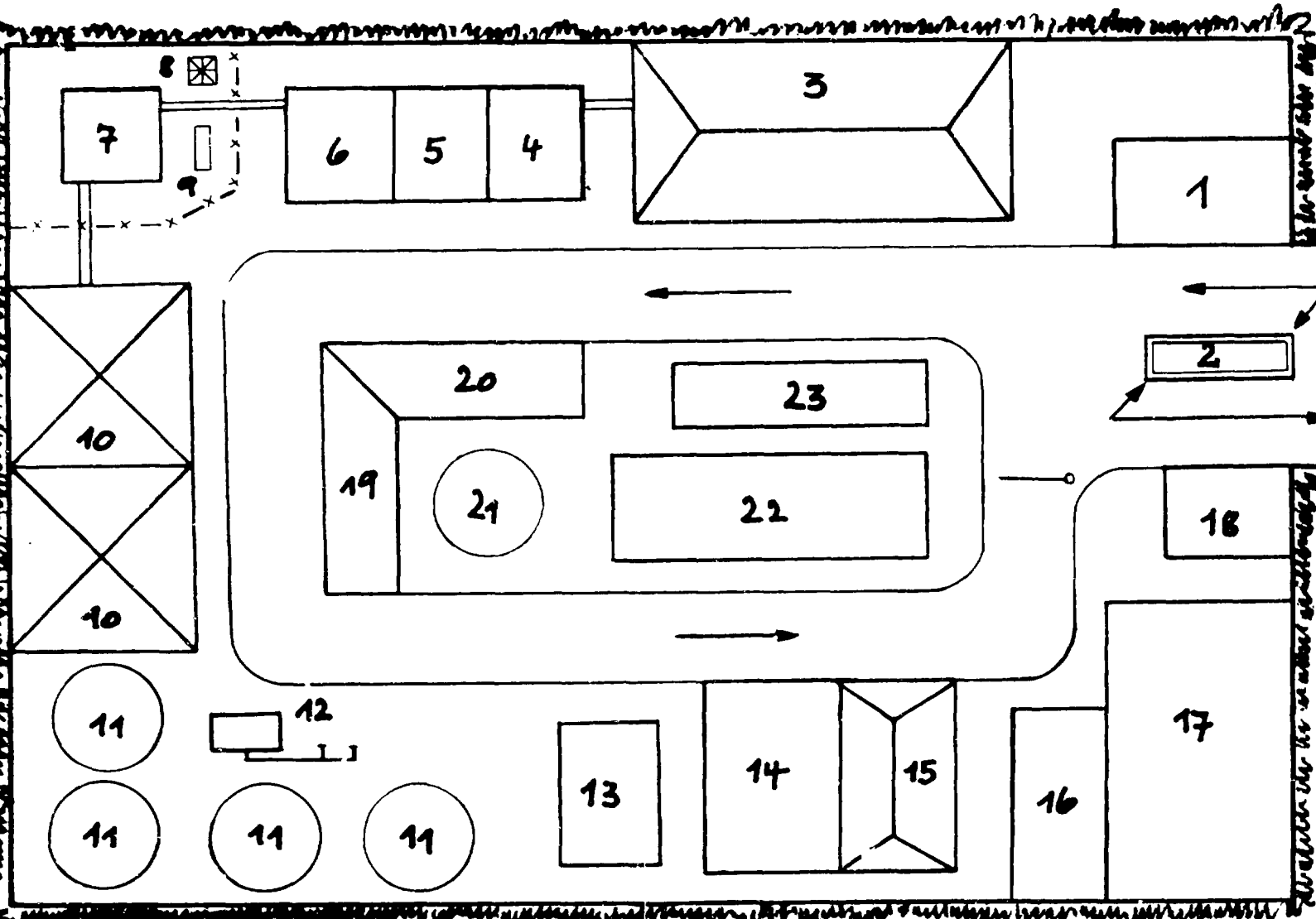
- a) Preparation of techno-economic surveys and sector studies in the oilseed processing industries sector of developing countries and the elaboration of master plans for short-term and long-term development;
- b) Establishment of pilot and demonstration plants for product and process development, and organization and supervision of applied research institutes and central quality-control laboratories;
- c) Co-ordination of the oilseed processing industry with related industries in order to adjust industrial production to market requirements.

Annex 1

Assumed Lay-out Plan of a Vegetable Oil Factory (Cottonseed Processing)

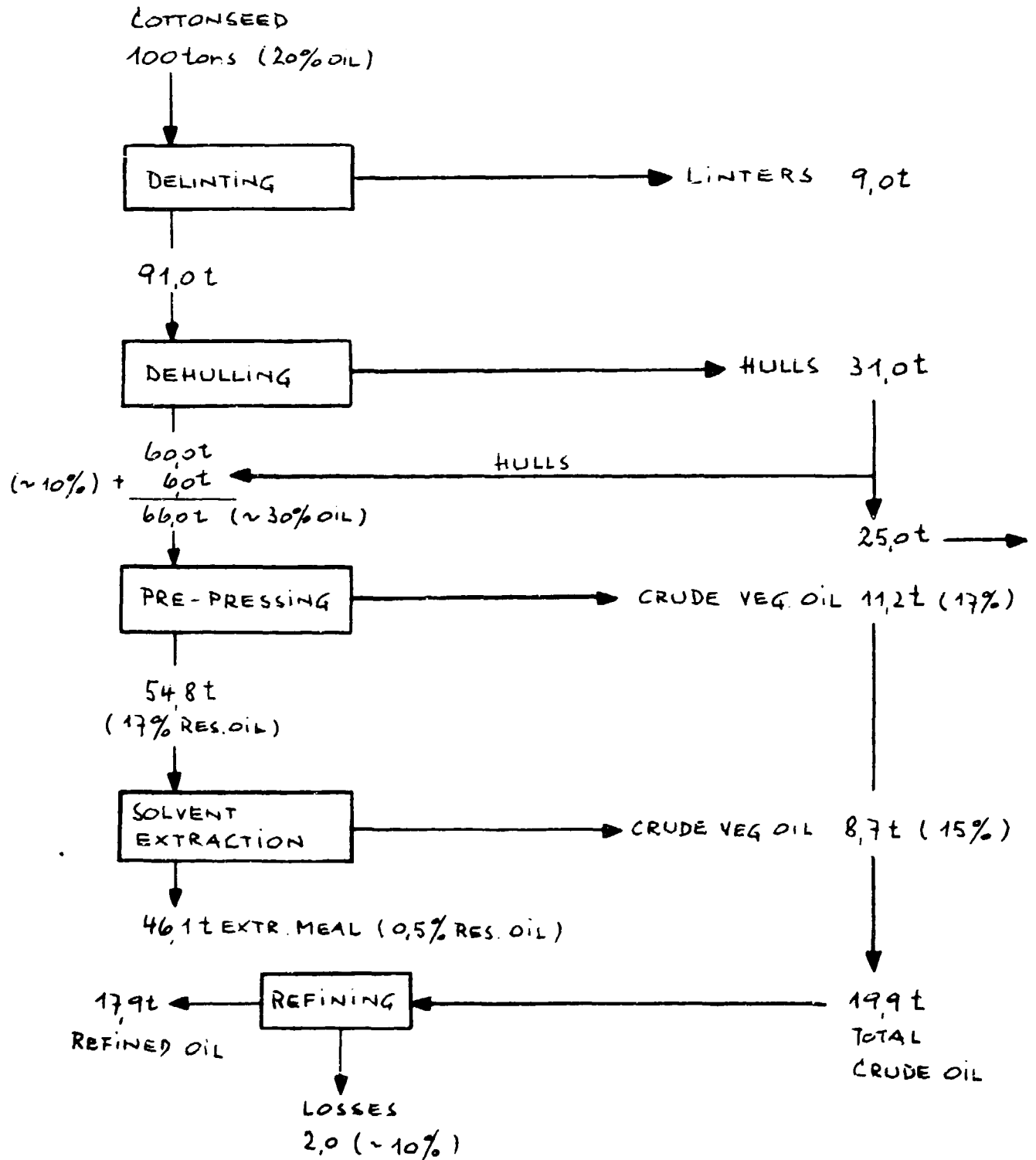
Nomenclature

1. Control station
2. Automatic balance
3. Raw material storage
4. Delinting
5. Dehulling
6. Preparation and pre-pressing
7. Solvent extraction
8. Water cooling system
9. Underground solvent tank
10. Meal storage
11. Crude vegetable oil storage
12. Pump- and filing station
13. Refining unit
14. Bottling and filing station
15. Refined oil warehouse
16. Laboratory
17. Office/Administration
18. Security engineer
19. Linter storehouse
20. Shell/hulls storehouse
21. Fuel oil tank
22. Boiler house
23. Mechanical workshop

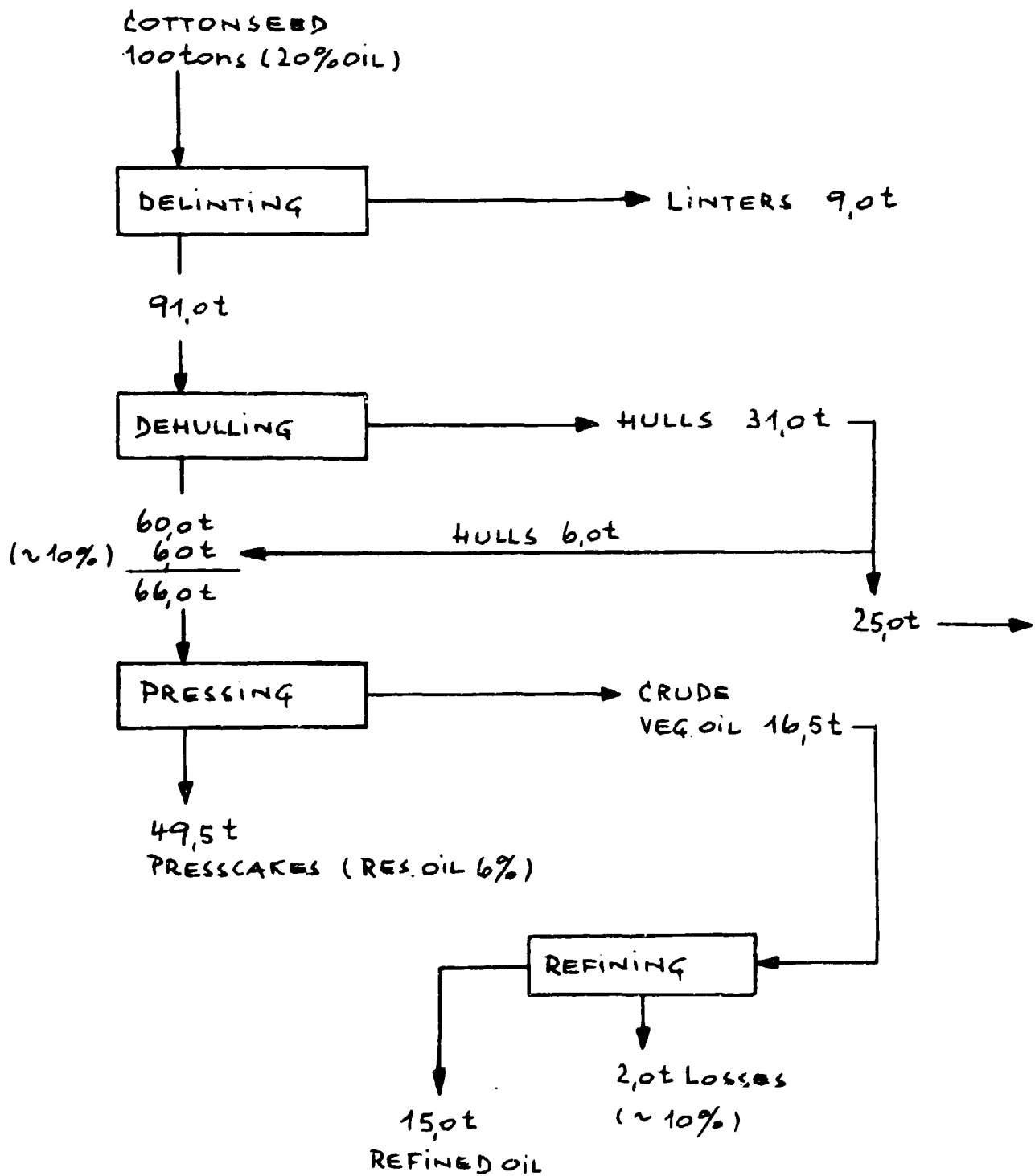


ANNEX 2

PRE-PRESSING AND SOLVENT EXTRACTION OF COTTONSEED



MECHANICAL PRESSING OF COTTONSEED



ANNEX 4

DIRECT SOLVENT EXTRACTION OF COTTONSEED

