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UNDERSTANDING PRESSURE EXTRACTION OF VEGETABLE OILS

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Understanding Pressure Extraction of Vegetable Oils

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PREFACE

This paper is one of a series published by Volunteers in Technical Assistance to provide an introduction to specific state-of-the-art technologies of interest to people in developing countries. The papers are intended to be used as guidelines to help people choose technologies that are suitable to their situations. They are not intended to provide construction or implementation details. People are urged to contact VITA or a similar organization for further information and technical assistance if they find that a particular technology seems to meet their needs.

The papers in the series were written, reviewed, and illustrated almost entirely by VITA Volunteer technical experts on a purely voluntary basis. Some 500 volunteers were involved in the production of the first 100 titles issued, contributing approximately 5,000 hours of their time. VITA staff included Betsey Eisendrath as editor, Suzanne Brooks handling typesetting and layout, and Margaret Crouch as project manager.

The authors of this paper are VITA volunteers. VITA Volunteer James Casten is a chemical engineer with experience in oil extraction, and has worked in Africa, South America, and Europe.

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VITA is a private, nonprofit organization that supports people working on technical problems in developing countries. VITA offers information and assistance aimed at helping individuals and groups to select and implement technologies appropriate to their situations. VITA maintains an international Inquiry Service, a specialized documentation center, and a computerized roster of volunteer technical consultants; manages long-term field projects; and publishes a variety of technical manuals and papers.

UNDERSTANDING PRESSURE EXTRACTION OF VEGETABLE OILS

**by VITA Volunteers James William Casten
and Harry E. Snyder**

I. INTRODUCTION

USES OF VEGETABLE OILS

Since the beginning of history, people have made use of the oils

obtained from seeds and nuts.

The principal use of these oils is as food. They are eaten raw and cooked, are a useful ingredient in baking, and serve as a means of transfer of heat in frying. Oils are a source of calories and of fat soluble vitamins.

Oils also have a number of nonfood uses. They serve as lubricants, and as a drying base for paints. They are boiled with alkali to make soaps, and are an ingredient in many cosmetics.

VEGETABLE SOURCES OF OIL AND FAT

Commercial Nuts and Seeds Used for Oil

The table below lists the seeds most commonly used commercially to obtain oil by means of mechanical pressing.(*)

Seed	Oil Content (%)	Use
Almond	50	Food, salad oil, soap
Castor	50	Medicine, lubricant
Cotton seed	30	Food, paint, resin
Hemp seed	35	Paint, varnish, soap
Linseed	40	Paint, soap, varnish, linoleum
Olive	40	Salad oil, cooking oil
Peanuts (groundnuts)	50	Salad oil, cooking oil

Perilla seed 50 Drying oil for paint, resin
Poppy seed 50 Salad oil, cooking oil
Rape seed (colza) 40 Salad oil, cooking oil
Sesame seed 50 Salad oil, cooking oil
Sunflower seed 35 Salad oil, cooking oil, soap
Tung nuts 20 Paint

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(*) Soybeans are not included in the list because their oil content of only 20 percent makes it impractical to extract oil from them by mechanical pressing. Soybean oil is recovered by solvent extraction.

Commercial Nuts and Seeds Used for Fat

Vegetable fats are semisolid at room temperature, whereas oils are liquid. Fats have a higher melting point than oils, and thus are heated before pressing. The table below lists common sources of vegetable fats.

Fat Content
Sees (%) Uses

Cocoa (cocoa) butter 40 Chocolate, food
Coconut oil from copra 50 Food, chemicals, soap
Hahua (illipe) butter 60 Food, candles, soap
Japan wax 30 Lubricant, leather dressing
Palm nut oil 50 Food, chemicals, soap
Shea butter 55 Food, candles, soap

II. METHODS OF EXTRACTING OIL FROM NUTS AND SEEDS

Oil can be extracted from nuts and seeds by heat, solvents, or pressure. Extraction by heat is not used commercially for vegetable oils. Extraction by solvents is dealt with in Understanding Solvent Extraction of Vegetable Oils by Nathan Kessler, in this same series. This paper deals with extraction by pressure.

Pressure extraction separates the oil from the solid particles by simply squeezing the oil out of the crushed mass of seeds. The simplest method is to fill a cloth bag with ground seed pulp and hang the bag so that it can drain. Some of the oil, called free run oil(*), flows out; the rest must be pressed out mechanically. The simplest way is by placing heavy rocks on the materials. Or bags of oil seed pulp can be placed one above another in a box or cylinder, and great pressure can be slowly brought to bear on the whole mass. A long lever such as the one shown in Figure 1 can

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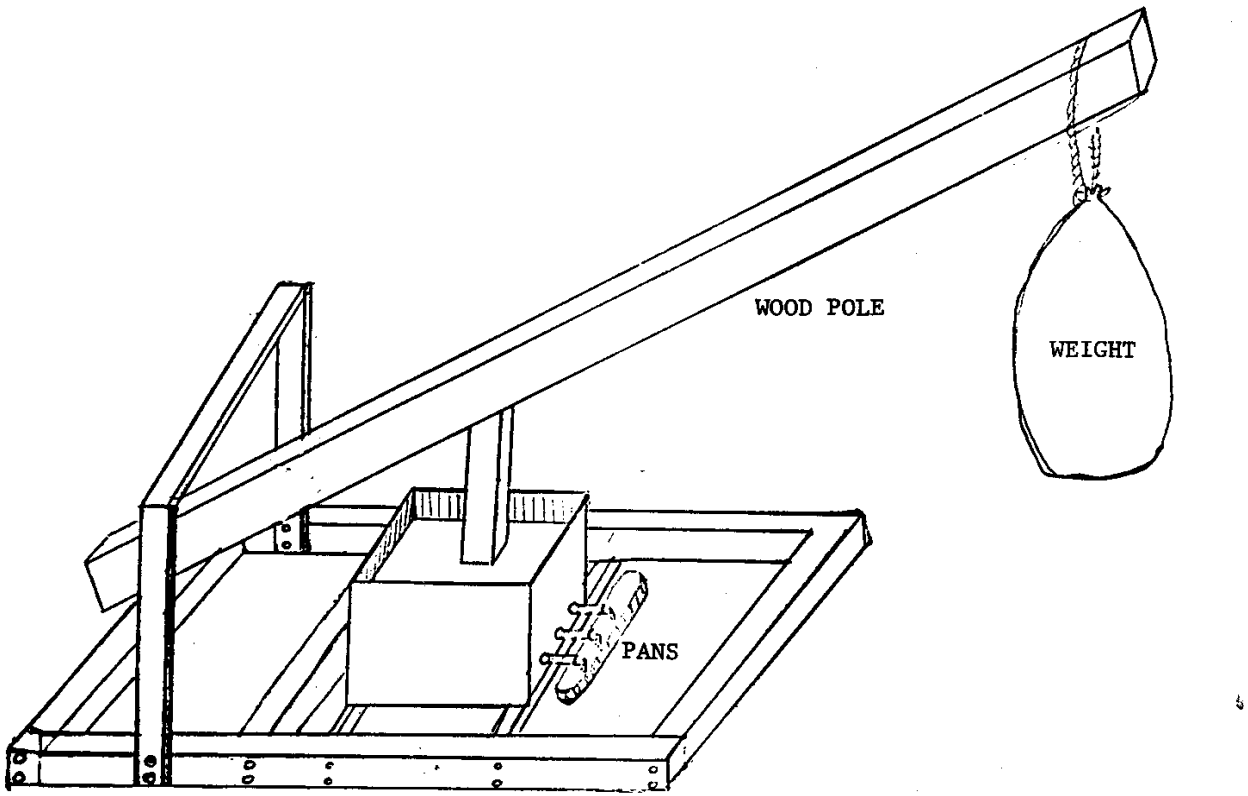

Figure 1. Lever and Box Press

exert up to 100 pounds per square inch.

Since greater pressure provides greater oil recovery, the lever

has often been replaced by heavy and strong mechanical jacks of several designs (screw jacks, ratchet jacks, and hydraulic jacks). A 20-ton jack can exert 1,000 pounds per square inch on a small cylinder of seeds.

(*) Terms in boldface are defined in the glossary at the end of this paper.

BATCH PRESSES

A batch press is a press that processes one batch of seeds at a time. Batch presses range from small, hand-driven presses that an individual can build to power-driven commercial press capable of processing many tons of seeds a day.

Small Batch Presses

Small batch presses are simple, but inefficient. However, they do work. They can be used in remote areas and can help determine whether there is a market for oil produced locally. Few resources are needed for an operation on this scale: wood fires for heating, and hand labor for pressing. Much hand labor is required to produce a small amount of oil this way.

If you plan to build a press in a remote area using only wood or locally available materials, VITA can send you some papers about processing oil seeds. Most companies listed in the Appendix sell batch presses, especially the Anderson and French firms in the

United States.

Advantages of small batch presses:

o They can be made of locally available materials.
o They can produce a good quality product.
o They are easy to repair.
o Their cost is low.
o They do not require trained operators.

Disadvantages of small batch presses:

o They are labor intensive.
o Complete recovery of the oil from the seeds is difficult. If seeds are plentiful, this is not a serious problem.

Commercial Batch Presses

Once a business is started, the market and cash flow may grow quickly. If that happens, the simple equipment just described may be outgrown. You must then get information on larger equipment from commercial sources. Larger, commercial batch presses are available from most of the companies listed in the Appendix.

The smallest commercial presses cost several hundred U.S. dollars and are hand-operated. Write to manufacturers for price and size.

If electric power is available, hydraulic presses are available for any capacity required. When writing to a manufacturer, describe the kind of seeds or nuts that are available and the amount you plan to process. Also give the type of electricity available, 50 cycle 220 volts for example.

At this scale of operation, seed storage and disposal of oil cake need to be considered carefully.

Hydraulic presses, which are suitable only for batch processing, may be powered either by hand or by electricity. In many parts of the world, they are the most practical and economical way to extract oil from seeds.

A hydraulic press <see figure 2> is simple in operation. The ground seed

upe2x4.gif (600x600)

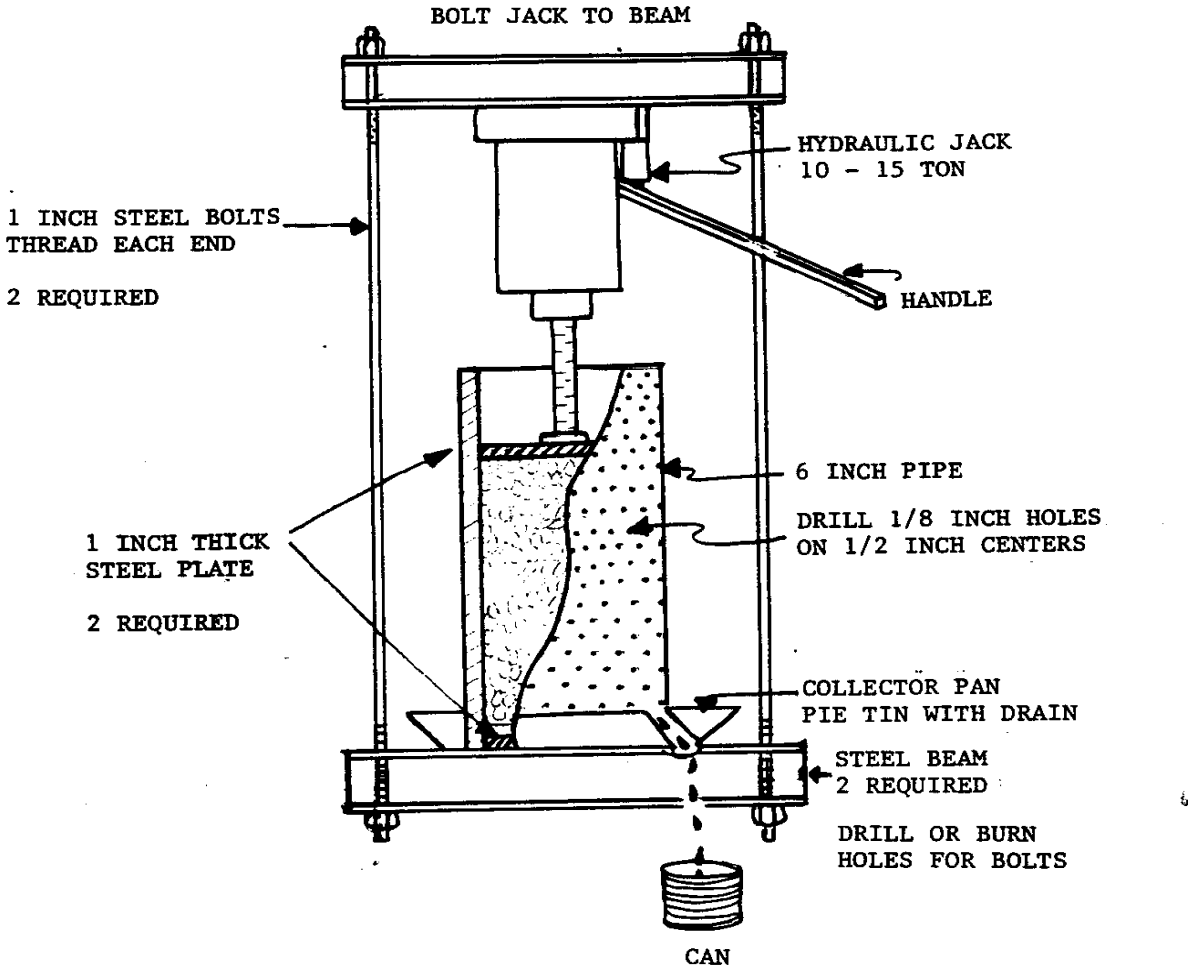

Figure 2. Hydraulic Oil Press

material or wet plant tissue is placed in the press in layers, with each layer separated from the next by a press cloth. Pressure is applied, slowly at first, and then increased as the

oil content in the tissue decreases. Maximum total pressure is 2,000 pounds per square inch for one inch layers. Total time to load the press, apply the pressure, and remove the cake, is approximately one hour. Drainage of the oil while under pressure may require 30 to 45 minutes. The amount of raw material that can be handled depends on the size of the press, which in turn depends on whether it is a hand press or is operated by electrical power.

Advantages of commercial-size batch presses:

- **They can be driven by hand or by electricity.**
- **They are economical to operate.**
- **They are simple to operate and maintain.**
- **Operators require only minimum training.**
- **Recovery of oil from seeds is excellent.**

Disadvantages of commercial-size batch presses:

- **The cost of the machinery is substantial, and delivery time may be long.**
- **Spare parts are difficult to obtain in remote areas (though they can be airmailed almost anywhere).**
- **Electric power, or generators to produce it, must be available to operate the larger models.**

EXPELLERS OR CONTINUOUS SCREW PRESSES

Expellers, or continous screw presses, are used throughout the

world for the expression of oil from copra, palm kernals, peanuts, cottonsees, flaxseed, and almost every other variety of seed, wherever there is a large enough seed supply to justify a continuous operation.

Expellers achieve the pressure needed to express the oil by means of an auger that turns inside a barrel. The barrel is closed, except for an opening through which the oil drains.

An expeller can exert much greater pressure on the seed cake than a hydraulic batch press can. This increased pressure permits the recovery of a larger proportion of the oil: generally, about 3 to 4 percent of the oil is left in the cake with an expeller, compared to 6 to 4 percent with a hydraulic press. The expeller is an essential part of almost all modern oil seed extraction plants. It is used both by itself and as a pre-press before

solvent extraction. Expellers vary in size from machines that process 100 pounds of seed per hour, to machines that process 10 or more tons of seed per hour. A three-horsepower machine for 40 kilograms per hour is shown in the Appendix.

Advantages of expellers:

o They are the most common type of mechanical extraction equipment in use commercially today.
o They require less labor than any other method.
o Where power is reasonable in cost, and labor is expensive, continuous expellers are economical.

o Plant capacity is higher than with batch equipment.
o Expellers extract a greater proportion of the oil than do hydraulic batch presses.

Disadvantages of expellers:

o Equipment must be purchased.
o Maintenance costs are high, and maintenance requires skilled mechanics. It is always best that the chief mechanic be sent to the machinery supply factory for training.
o More energy is required than for batch processing.
o Electric Power is required for the press and for auxiliary equipment.
o The press must operate continuously for at least eight hours; intermittent operation is unsatisfactory.
o Oil from an expeller has more impurities than oil from a batch press, and must be heated and filtered to obtain a clean oil.

CHOOSING YOUR METHOD

The type of press that is appropriate depends largely on the size of the operation. Oil processing operations range in size from cottage industries processing only a few pounds of seed per day, to factories processing as much as 3 or 4 thousand tons of seed per day.

For small operations (processing less than 1 ton of seed per

day) , the right equipment is almost always a form of batch press.

If 1 or more tons per day are to be pressed, the right equipment is most often an expeller.

III. SEQUENCE OF OPERATIONS

The sequence of operations in processing oil seed for pressing is as follows:

STORAGE

The seeds, nuts, or plant tissue containing the oil must be properly stored and prepared for extraction, to maintain high quality in the final product.

If the oil-bearing material is dry, it must be stored so that it remains dry, for optimum extraction and quality of the oil. If the oil-bearing material is wet plant tissue, it should be processed for oil-extraction as soon as possible after harvest so that storage time is kept to a minimum. Oils in the presence of water deteriorate rapidly, forming free fatty acids and rancid off-flavors.

CLEANING

After the oil-bearing materials have been removed from storage, the first step in preparing them for oil extraction is to clean

them. The cleaning is done so that the oil is not contaminated with foreign materials, and so that the extraction process can proceed as efficiently as possible.

Inspect the seeds carefully and remove stones, sand, dirt, and spoiled seeds. Dry screening is often used to remove all material that is over or under size. Washing is possible, but it is important to try to avoid wetting tissue that would have to be dried later.

DEHULLING

After raw material has been cleaned, it may be necessary to remove its outer seed coat. There are a couple of reasons for doing this. The seed coat does not contain oil, so including it makes extraction less efficient. Also, the next step will be grinding to reduce particle size, and any tough seed coats interfere with this process.

Some seeds, such as peanuts, can be shelled by hand. Some others, such as sunflower seeds, are usually hulled in machines. Still others, like safflower and colza, cannot be shelled. If the seed coat is a small part of the whole seed and presents no problem in grinding the seed, it may be left on.

GRINDING OR ROLLING

Seed is not usally pressed whole, since oil extraction is more

efficient if the seed is in smaller particles. Grinding the oil seed is one effective way to reduce particle size. A hand-operated mortar, millstone grinder, or even a kitchen meat grinder can be used to convert the seeds to a coarse meal. Small hammer mills, motor or hand-powered, are also good.

Another way to reduce particle size is to roll the oil seeds to produce flakes for extraction. Many commercial extraction plants find this the most effective approach. With large oil seeds it may be necessary to grind the seed first, and then put the pieces through flaking rollers.

Either process makes the actual pressing more efficient. The final piece size that leads to most efficient extraction can best be determined by experiment, as the size will vary depending on the kind of seed and the kind of pressing operation. Generally, smaller-size pieces are better for oil removal. But if the pieces are too small, they may contaminate the oil and be difficult to remove from the final product.

HEATING

A final step in raw material preparation is heating the ground or flaked oil seed. The exact reason that heating improves oil extraction is unknown, but it does increase yields. Also, heating is useful if there are enzymes in the plant tissue that have a deteriorating effect on the oil quality. If the oil seed cake (that is, the residue remaining after oil removal by pressing) is to be used for feed or food, heating may be useful

in increasing protein availability.

Sometimes oil-bearing material is pressed without being heated. Oil extracted in this way is called cold press oil.

PRESSING

The materials prepared in these ways are pressed, usually in a lever press, hydraulic press, or expeller, to remove the oil.

REFINING

Cold press oil can be of such high quality as to need no refining if it comes from seeds that are fresh and of good quality.

All other oil, especially that which has been pressed from lower quality feedstock, is likely to have some undesirable cloudiness, color, or flavor that needs to be removed.

Removal of Cloudiness

Pressed oils need to be filtered to remove particles from the pressing operation, if the oil is to be clear and clean.

If the cloudiness is caused by gums precipitating, the gums can be removed by washing the oil with about 2 percent water. For this process to be effective, the oil should be heated, and the hot oil mixed with water, with active stirring. Next the water and oil must be separated. For this, a centrifuge is most

effective. The degummed oil should be dried by heating to drive off all moisture, for the reasons cited previously.

Removal of Excess Color

For the removal of excess color, bleaching earths are effective. The oil is heated and mixed with 1-2 percent of its weight of an effective bleaching earth purchased from a reliable supplier for this purpose. After a contact time of approximately one hour, the bleaching earth is separated by filtration. Activated carbon can also be used.

Removal of Unwanted Flavors

Unwanted flavors are more difficult to remove. They may be due to excessive free fatty acids. If the oil-bearing material is stored at a high moisture level, or if they material is bruised or broken or moldy, it becomes more difficult to press, and the free fatty acid content of the oil extracted from it usually increases. Free fatty acids in fresh olive oil vary from 1/2 of 1 percent to 3 percent. Acidity of over 10 percent is common; if over 20 percent acid, the oil is good only for making soap.

Free fatty acids can be removed from the oil by washing the oil with alkali: put 25 to 30 gallons of the rancid oil in a 55-gallon steel drum with an open top. Add 15 gallons of water with 2 1/2 pounds of soda ash dissolved in it. Mix well with a big wire whip or paddle to mix the oil and water solution. The fatty acid will react with the soda to form soap, which stays in the

water phase.

Let the layers separate for several hours and siphon off the oil layer. If the oil still contains fatty acids, you should repeat the operation. There will be a loss in volume because the free fatty acids may account for 10 to 20 percent of the original volume. If emulsions form, you can heat the mixture, which will usually cause a separation. It is a good idea to heat the refined oil to drive off any remaining water. This method works well without your needing to send the oil to a laboratory for analysis to determine how much soda ash to add. An experienced operator is the best substitute for a chemical laboratory.

It is important to use clean equipment, so wash all the utensils well at the end of the day. Also, allow no copper in the plant. Copper and certain other heavy metals cause undesirable changes in oils. For example, heating butter in a copper vessel will quickly impart a fishy taste to the butter. Even a copper bolt in a press can damage the flavor of your product. Use cast iron, or stainless steel, but no copper or copper-bearing materials.

Other types of flavors than those of fatty acids can be removed from oil, but an expensive and difficult process known as deodorization is used. It involves distilling off the unwanted flavors under high heat and high vacuum. Normally the oils being processed by small-scale pressing would have the flavors of the raw material from which they came, and there would be no need for deodorization.

IV. FINAL CONSIDERATIONS

One of the best sources of information about oil pressing on a small scale is the small oil processor in the region of interest. Very seldom will an oil processor be the first in a region to attempt oil extraction. Locate those individuals already in the business of extracting oil from vegetable materials and learn what kinds of equipment and raw materials they have had success with, and what kinds of problems they have run into.

In remote villages where oil seeds are plentiful, but mechanics and machinery are not, a lever press or hydraulic press can be a convenient means of supplementing expensive imported cooking oils.

Commercial-scale edible oil production, however, is not a cottage industry. The extraction and refining of oils and fats suitable even for local markets is a highly technical and capital intensive process. It is large, efficient plants that are the ones likely to make a reasonable profit. The vegetable oil extraction industry is a highly competitive commodity industry in which the price of oil is established and the price of oil seeds fixed by the commodity market. If domestically grown oil seeds are exported, then a local oil press will have to pay the same price for seeds as its foreign competitors do. The small local firm's costs of doing business are likely to be as high or higher than those of its competitors abroad. Tariffs or subsidies may be required to protect the home industry. An expeller plant can sometimes allow a small country to become independent of imported

oils, but the cost of the oil extraction plant may be higher than the cost of the imported oils.

EQUIPMENT MANUFACTURERS: OIL PROCESSING

Anderson International Corporation
19699 Progress Drive
Strongsville, Ohio 44136, USA

Crown Iron Works
P.O. Box 1364
Minneapolis, Minnesotta 55440, USA

CeCoCo
P.O. Box 8, Ibaraki City
Osaka Pref. 567, JAPAN

French Oil Millers
P.O. Box 920
Piqua, Ohio 45356, USA

Hander Oil Machinery Corporation
Osaka, JAPAN

S.P. Engineering Corporation
P.O. Box 218, 79/7 Latouche Road
Kampur, INDIA

Stork Company Apparatenfabriek, N.V.

Roorstraat
Post-Bon 3007
Amsterdam, HOLLAND

Rose, Downs and Thompson, Ltd.
Old Foundry
HU11, ENGLAND

Officine Meccaniche Angelo e Tullio Bosello
VIllatera de Saonara
Padova, ITALY

Mathias Reinartz Maschinewfabril
P.O. Box 137, Industriestrasse 14
404 Neuss, WEST GERMANY

IBG Monforts and Reiners, P.O. Box 516
4050 Monchengladbach 2, WEST GERMANY

ORGANIZATIONS INVOLVED WITH OILSEED PROCESSING

CANOLA
301433 Main Street
Winnipeg, Manitoba
CANADA R3B 1B3

Cotton Development Board
P.O. Box 371
Tamale, GHANA

International Centre for Agricultural Research
P.O. Box 5466
Alleppo, SYRIA

Khadi Village Industries Commission
Irla Road
Vileparle, Bombay 56, INDIA

Makeni Ecumenical Centre
Box RW 255
Lusaka, ZAMBIA

Malkerns Research Station
P.O. Box 4
Malkerns, SWAZ ILAND

National Cottonseed Products Association
P.O. Box 12023
Memphis, Tennessee 38112, USA

National Horticultural Research Station
P.O. Box 220
Thika, KENYA

Nigerian Institute for Oil Palm Research
Benin-Lagos Road Benin City
Bendel State, NIGERIA

Punjab Vegetable Ghee Board
5 Bank Square
Lahore, PAKISTAN

GLOSSARY

Free run oil - The natural accumulation and drainage of oil from seed pulp, without the use of a press.

Oil cake - The residue left after pressing.

Dry screening - The manual removal of under- or over-sized seeds before pressing.

Cold press - The pressing of oil bearing seeds, pulp, or cake that have not been heated.

Emulsions - Any colloidal suspension of a liquid in another liquid.

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