OIL EXTRACTION

PRACTICAL ACTION
Technology challenging poverty

technical brief

Oil is extracted from several seeds, nuts and fruits (Table 1 provides some common examples) for use in cooking and soapmaking[1], cosmetics, detergents, or as an ingredient in other foods such as baked or fried goods.

	Moisture content (%)	Oil/fat content (%)
Seeds and beans		
Cotton	5	15-25
Rape	9	40-45
Mustard	7	25-45
Sesame	5	25-50
Sunflower	5	25-50
Safflower	5	30
Nuts		
Coconut (fresh)	40-50	35-40
Copra	3 – 4.5	64-70
Groundnut (shelled)	4	28-55
Palm kernel nuts	-	-
(shelled)	-	46-57
Shea nut	-	34-44
Shea nut	-	-
Fruits		
Oil palm	-	56
Avocado	69	11-28
Olive	50-70	-

Table 1: Sources of oil.

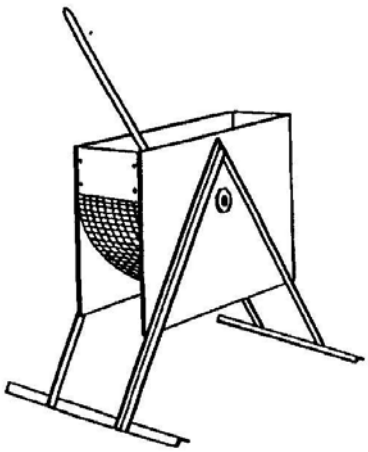

Figure 1: A groundnut decorticating machine

Raw material preparation

Oilseeds and nuts should be properly dried before storage, and cleaned to remove sand, dust, leaves and other contaminants. Fruits should be harvested when fully ripe, cleaned and handled carefully to reduce bruising and splitting. All raw materials should be sorted to remove stones and mouldy nuts. Some moulds, especially in the case of groundnuts, can cause aflatoxin poisoning. When storage is necessary, this should be in weatherproof, ventilated rooms which are protected against birds, insects and rodents. Some raw materials (for example groundnuts, sunflower seeds) need dehusking (or decorticating). Figure 1 shows a simple manually-operated groundnut decorticating machine. Decortication is important to give high yields of oil and reduce the bulk of material to be processed. However, expellers normally require a proportion of fibrous material in order to work and, particularly with groundnuts, some husk is normally added to allow oil to escape more freely from the press. Coconut is dehusked and split manually by skilled operators. Most oilseeds (eg copra, palm kernels and groundnuts) need grinding in mills before oil extraction to increase the yield of oil. A separate Technical Brief provides details of coconut processing.

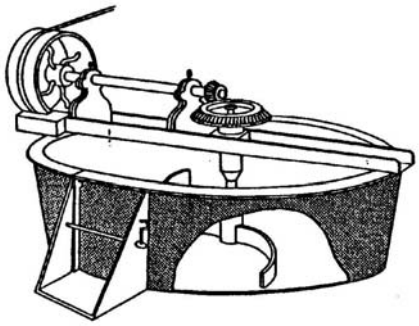

Figure 2: A seed scorcher

[1] See Technical Brief: 'Soapmaking'.

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Some seeds (especially groundnuts for example) are conditioned by heating to 80-90^{o}C using a seed scorcher (Figure 2 shows a typical small-scale example – a separate heat source is necessary beneath the scorcher). All oil-bearing materials need to have the correct moisture content to maximise the oil yield. Using small-scale expellers, oilseeds and nuts are usually processed "cold" (ie without additional heating).

Oil Extraction Methods
Extraction methods include:

- Manual presses
- Ghani
- Expeller
- Solvent extraction

Traditional methods
Oil is extracted from, for example, fresh coconut, olive, palm fruit shea nut by separating the flesh and boiling it in water. Salt can be added to break any emulsion which is commonly formed and the oil is skimmed from the surface. In palm oil processing the fruit is first heated in a 'digester'.

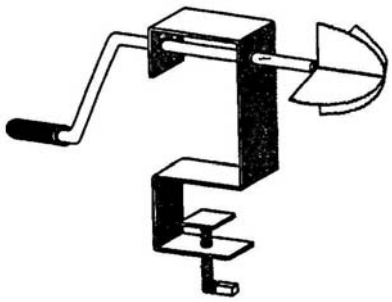


Figure 3: A manual coconut grater

Manual methods
Oil can be extracted by pressing softer oilseeds and nuts, such as groundnuts and shea nuts, whereas harder, more fibrous materials such as copra and sunflower seed can be processed using ghanis. Pulped or ground material is loaded into a manual or hydraulic press to squeeze out the oil-water emulsion. This is more efficient at removing oil than traditional hand squeezing, allowing higher production rates.

Fresh coconut meat is removed from the shell using a manual or motorised grater (Figure 3). See Technical Brief on Coconut Processing for details of wet processing of coconuts.

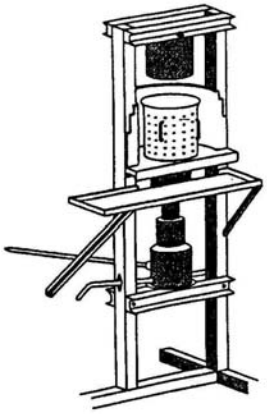
Equipment required

The equipment needed to set up a small or medium scale oil extraction enterprise falls into four main categories:

- pre-extraction equipment; dehullers or decorticators, seed/kernel crackers, roasters, grinding mills.
- extraction equipment; ghani, manual bridge press or ram press, expellers
- equipment for basic refining of the oil; filters, settling tanks for caustic soda to treat free fatty acids FFA (do not use aluminium tanks).
- packaging equipment.

The specific equipment required will depend on the particular crop being processed, the final oil quality required and the scale of operation.

Presses have a number of different designs, commonly based on a bridge press. In all types, a batch of raw material is placed in a heavy-duty perforated metal 'cage' and pressed by the movement of a plunger.
The amount of material in the cage varies from 5-30 kg with an average of 20 kg. Layer plates can be used in larger cages to provide a constant pressure through the bulk of



material and speed up removal of oil. The pressure should be increased slowly to allow time for the oil to escape. Screw types are more reliable than hydraulic types but are slower and produce less pressure. Except where a lorry jack is used (Figure 4), hydraulic types are more expensive, need more maintenance, and risk contaminating oil with poisonous hydraulic fluid.

Figure 4: Oil press with a hydraulic jack

Ram Press
A long pivoted lever moves a piston backwards and forwards inside a cylindrical cage constructed from metal bars spaced to allow the passage of oil. At one end of the piston's stroke, it opens an entry port from the seed hopper so that seed enters the press cage.

When the piston is moved forward, the entry port is closed and the oilseed is compressed in the cage. As a result, oil is expelled from the oilseed and emerges through the gaps in the cage. Compressed seed is pushed out through a circular gap at the end of the cage.

Figure 5: Ram press. Photo: Tony Swetman

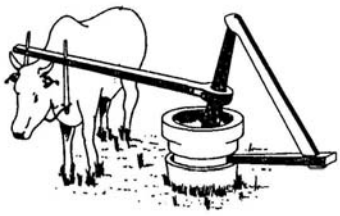
Ghanis are widely used in Asia but less so in other areas. A heavy wooden or metal pestle is driven inside a large metal or wooden mortar (Figure 5a*)*. The batch of raw material is ground and pressed and the oil drains out. They have relatively high capital and maintenance costs and need skilled operators to achieve high oil yields.

Mechanised extraction

Ghani

The ghani consists of a large mortar and pestle, the mortar being fixed in the ground and the pestle being moved within the mortar by animal traction (donkey or mule) or (more commonly) a motor. Oilseeds are placed in the mortar and the pestle grinds the material to remove the oil. The oil runs out of a hole in the bottom of the mortar and the cake is scooped out by hand. This method is slow and requires two animals, replacing the tired one with another after about 3-4 hours of work.

Motorised ghanis (Figure 5b) are faster than manual or animal types but are more expensive and their higher capital and operating costs will require a larger scale of production for profitability.



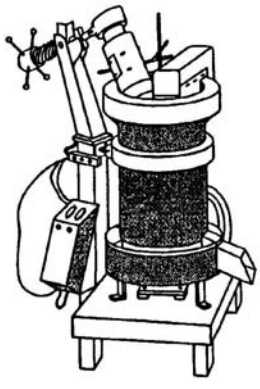


Figure 5a: Animal powered extraction Figure 5b: motorised extraction

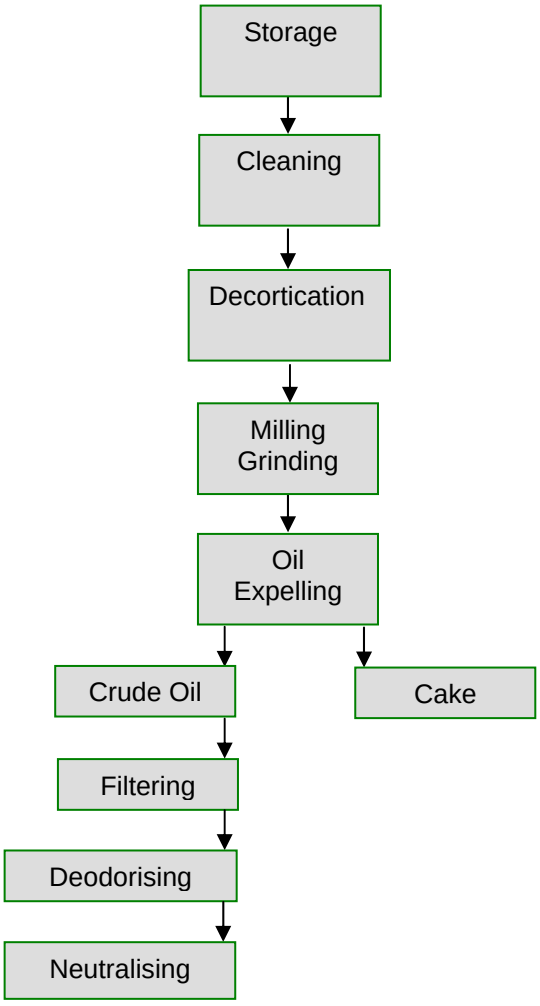
The width of this gap, which can be varied using an adjustable

pressure cone, controls the operating pressure of the press. The design of the press is such that it can achieve operating pressures in excess of those obtained in most manually operated cage presses and as high as those in small expellers. The ram press has a low seed throughput but has the advantage of continuous operation. The ram press was developed in Tanzania specifically for processing a thin shelled high oil content variety of sunflower seed. The technique can also be used for copra, groundnuts and sesame.

Expeller

The basic steps involved in processing oilseeds by expeller are shown in the flow diagram below.

Flow diagram



An illustrated description of the working of an expeller is available at:
http://www.rosedowns.co.uk/press_basics/Press_Parts.htm

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Figure 6: Rosedowns Maxoil press. **Photo: Tony Swetman.**

An expeller consists of a helical thread (*worm assembly*) which revolves concentrically within a perforated cylinder (*the cage or barrel*). The barrel is usually formed by a series of axially-placed *lining bars* contained within a robust frame.

Figure 7: Typical view of cage or barrel of an expeller. Photo: Tony Swetman.

Heated oilseeds enter one end of the barrel through the feed inlet and are conveyed by the rotating worm assembly to the discharge end. With any power-driven equipment, it is important to consider how the equipment will be repaired as it becomes worn. Local refurbishment is normally cheaper than importing spare parts.

Solvent extraction plants use hexane as a solvent to extract oil from oilseed cake. These plants are expensive and only suitable for large volumes which justify the capital cost of equipment. Where large amounts of oilseed cake are available, solvent extraction becomes a commercially-viable option to extract the residual oil left in the cake and leave an almost oil-free powder known as oilseed meal. Both cake and meal are incorporated in animal feeds.

Clarification of oil

There is always some finely-divide material expelled with the oil and this is termed *foots*. Foots are collected on a sieve which is continuously scraped and the foots re-processed in the expeller. Oil is transferred to a holding tank prior to filtration under pressure through special filter cloths.

Figure 8: Typical filter press. Photo: Tony Swetman

These materials are removed by clarification – either by letting the oil stand undisturbed for a few days and then separating the upper layer, or by using a clarifier (Figure 9). This consists of an oil drum placed above a fire. The oil is boiled to drive off water and destroy naturally occurring enzymes and contaminating bacteria. The oil is allowed to stand and contaminants the separate out. The oil is filtered through a cloth and heated briefly to 100°C to boil off any remaining

traces of moisture. This is usually sufficient at the small scale to meet the quality needs of customers and give a shelf life of several months when correctly packaged.

Refining
In many local markets further refining is not required as the flavours of unrefined oils may be readily acceptable. However these stages are carried out in large-scale operations and for international markets which tend to prefer a less-coloured and odourless product.

These refining steps are:

- *Neutralisation*
  Fatty acids can be neutralised by adding a sodium hydroxide solution, also known as caustic soda, or by stripping, which is a similar process to de-odorising.
- *Bleaching*
  Some oils have a very dark colour which can be unpopular with consumers. The appearance of the oil can be lightened by bleaching.
- *Deodorising*
  Volatile compounds that produce odours can be eliminated through the process of sparging, i.e. bubbling steam through the oil, under a vacuum.
- *Degumming*
  Degumming is a way of treating oils that have a high phosphotide content. The phosphotide, which makes a gummy residue, is removed by mixing the oil with 2 or 3 % water. This hydrated phosphotide can then be removed by settling, filtering or centrifugation.
- *Winterisation*
  Allowing the oil to stand for a time at low temperatures so that glycerides, which naturally occur in the oil, with higher melting points solidify and can then be removed from the oil by filtering. This step is usually carried out with palm oil to separate the oil into two separate products: a solid fat (stearin) and a liquid oil (olein).

Packaging and storage of oil
If incorrectly stored, some types of oil rapidly go rancid and develop an unpleasant odour and flavour. The main factors that cause rancidity (in addition to moisture, bacteria and enzymes above) are light, heat, air and some types of metals. To obtain a shelf life of several months, oils should be stored in lightproof, airtight and moisture-proof containers in a cool place. Tin-coated cans, glazed pottery, glass and food-grade plastics are all suitable when properly sealed. Great care is needed to remove all traces of oil from re-useable containers, and to thoroughly dry them before re-filling, because any residual moisture or rancid oil on the inside will rapidly spoil fresh oil. The materials used to make processing equipment and containers should not contain copper as it promotes rancidity.

Use of by-products
All oilseed cakes can be used as livestock feed ingredients with suitable pre-treatments where required. Often, when low-temperatures are used for oil extraction, the cake can be incorporated into food. However, all oil extraction businesses need to identify markets for their by-products to maximise income. Quality assurance
The main quality checks concern raw materials, processing conditions, product quality (conformity to the standards applicable in the market into which the oil is sold) and packaging and storage conditions. Raw materials should be checked to ensure that there is no mould growth, and that they are correctly dried, cleaned and sorted so no other seeds or contaminants are present. During processing, the temperature and time of conditioning, the moisture content of the raw material, and the yield of oil should be routinely checked. Quality checks on the product include correct colour, flavour, odour, clarity and fill weight.

Oil processing as a business
The profitability of all businesses, including oil processing, depends on reducing the capital and operating costs as much as possible, and at the same time maximising the income

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from the sale of oil and by-products. A careful study of all costs should be undertaken before setting up a production unit. In particular the cost of the main pieces of equipment, salaries for the expected number of workers, and the prices for raw materials, fuel and power should be assessed.

The price that can be charged for oil and by-products depends on a number of factors including quality, packaging, and the number, type and quality of competing products. These should each be assessed in order to calculate the likely income at the planned scale of production over the year. The production costs can then be compared with the expected income to calculate the likely profitability. In most cases, it is necessary to make full use of the by-products to make the enterprise financially successful.

Different systems are used for marketing and selling oils and by-products, and it is necessary to select one that meets the needs of consumers, while at the same time keeping the sale price as low as possible. Oil can be sold from bulk drums into customers' containers in markets or at the production site or it can be packaged into retail or bulk containers and transported to towns for sale. The major by-product (oilseed cake is a useful ingredient in livestock feed and is usually sold in bulk to poultry or animal producers or to animal feed processors.

One problem that faces oil processors is to ensure that there are adequate supplies of raw material to operate at the planned production rate throughout the year. It is likely that crops will be bought during harvest time when prices are lowest, but it may be necessary to offer an incentive for farmers to supply the processing unit, rather than sell on the open market. A simple contract to buy a specified amount of crop at a fixed price can benefit both farmers and processors, provided both parties keep their side of the agreement. Oil processors also need a large working capital to buy the year's supply of seasonal crops, and adequate storage facilities so that they remain in good condition until they are processed.

In summary, ensure that an adequate financial and technical feasibility study is done before investing any money in an oil processing venture. Indicative questions to ask before setting up a small-scale oil extraction business include:

- What is the local demand for oil and by-products?
- What is the existing level of competition?
- Are there enough oilseeds/nuts/fruit grown in the area for year-round processing?
- Will you be able to buy it at an acceptable price, or is it already contracted to other producers?
- Will unrefined oil be acceptable to consumers?
- What price will they pay per unit of oil?
- What is the preferred unit of oil to purchase?
- How should it be packaged?
- What price can the by-products be sold for?
- What are the costs of packaging and distribution?
- Can you afford the cost of equipment without a loan?
- If a loan is needed to buy equipment and a year's supply of crop, how long will it take for the expected income to cover the loan re-payments?
- Is the projected business economically viable?

Equipment suppliers
Note: This is an indicative list of suppliers and does not imply endorsement by Practical Action.

Ram Press – Kick Start Technologies (NGO in Kenya)
http://kickstart.org/tech/technologies/oilprocessing.html

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Oilseed processing equipment mostly from India
http://trade.indiamart.com/offer/plant-machinery/oil-extraction-machinery/sell1.html

Palm oil press
http://agic.en.alibaba.com/product/50324983/202880085/Oil_Press/palm_oil_press.html

Oil press machinery – China
http://lightinfo.en.ec21.com/product_detail.jsp?group_id=GC01966495&product_id=CA01985734&product_nm=200A-3_Oil_Press

De Smet Rosedowns
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E-mail: info@Rosedowns.co.uk
Website: http://www.rosedowns.co.uk/products/Product_Range.htm
Medium- to large-scale expellers and solvent extraction

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Oil expellers and ancillary equipment

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Tel: +1 419 448 0791
Fax: +1 419 448 1203
Website: http://www.csbellco.com/index.htm
Grinding mills

TinyTech Plants
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Fax: +91 281 2467552
Email: tinytech@tinytechindia.com
Website: http://www.tinytechindia.com/
Oil expellers and ancillary equipment

Azad Engineering Company
C-83, B.S.Road, Industrial Area Ghaziabad - 201 009 Ghaziabad, Uttar Pradesh, INDIA
PIN-201 009
Tel: +91 (0)120 470 0708
Fax: +91 (0)120 470 2816
Website:http://snsvo1.seekandsource.com/azad/
Oil expellers and filters

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Email: hander-taka@occn.zaq.ne.jp

- Oil expellers
- Filter press
- Seed scorcher
- Patented fresh coconut oil extraction plants

Website: http://www.occn.zaq.ne.jp/hander/index~english7.html

Useful contacts and further information
Further information can be obtained from the following sources:

- *Coconut Processing* Practical Action Technical Brief
- *Oilseed processing for small-scale producers* http://attra.ncat.org/attra-pub/PDF/oilseed.pdf
- *Small-scale Rural Oilseed Processing in Africa* http://www.idrc.ca/en/ev-26984-201-1-DO_TOPIC.html
- *The Manual Screw Press for Small Scale Oil Extraction*, K.H.Potts and K. Machell, 1993, IT Publications, 103-105 Southampton Row, London, WC1B 4HH, UK.
- *Post-Harvest Operations*, Chapter 6: Oilseeds, O.G. Schmidt (Ed), 1989. International Development Research Centre (IDRC), 250 Albert St., Ottawa, KIG 3H9 Canada (available online at http://www.fao.org/inpho/content/compend/text/ch05-01.htm#TopOfPage or from FAO Publications, Viale delle Caracalla, 00100, Rome, Italy.
- *Oilseed Crops*, E.A. Weiss, 2nd Edn., 1999, Iowa Satae University Press, 2121 State Avenue, Ames, Iowa, 50014-8300, USA
- *Ghani: a traditional method of oil processing in India*, K.T. Achaya, 1993, FAO Publications. Available online at: http://www.fao.org/DOCREP/T4660T/t4660t0b.htm
- *Catalogue of Small Scale Processing Equipment*, S Maneepun, IFRPD, Kasetsart University, Thailand. Available online at: http://www.fao.org/docrep/X5424E/X5424E00.htm
- *Small Scale Food Processing - a guide to appropriate equipment*, P.Fellows and A. Hampton, 2002, IT Publications/CTA,
- *Quality Assurance for Small Rural Food Industries* P.Fellows, B. Axtell & M. Dillon, 1995, Technical Bulletin 117, FAO Publications. Available online at: http://www.fao.org/docrep/V5380E/V5380E05.htm#Chapter%201.%20Basic%20principles
- *Starting a Small Food Processing Business*, P.Fellows, E. Franco & W. Rios, 1996, IT Publications.

www.fao.org/inpho	A compendium of post-harvest operations containing details of oil processing operations and equipment.
www.fao.org.agris	Contains news of science research in developing countries, and access to science journals and FAO databases via its documentation centre.

www.oilseed.org website of the National Institute of Oilseed Products, has an international membership of companies, including processors, equipment suppliers, importers and exporters.

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