800-346-9140

ATTRA
Appropriate Technology Transfer for Rural Areas

SMALL-SCALE OILSEED PROCESSING

VALUE-ADDED & PROCESSING GUIDE

ATTRA is the national sustainable agriculture information center funded by the USDA's Rural Business -- Cooperative Service.

Abstract: *This publication describes the basic processes involved in small-scale oilseed processing. Included are a low-tech method for raw material preparation using sunflower seeds as an example; information on methods and equipment used for oil extraction; and notes on clarification, packaging, and storage. Sources for additional information and a list of suitable raw materials are provided.*

By Janet Bachmann
NCAT Agriculture Specialist
February 2001

Introduction

Small-scale oilseed processing is of interest as a potential on-farm or community enterprise that can increase income and employment in rural areas (1). Many seeds, nuts, and kernels contain oil that can be extracted and used in cooking, as an ingredient in other foods, as a nutritional supplement, and as a raw material for the manufacture of soap, body and hair oils, detergents, and paints. Some of these oils may also be used to replace certain petroleum-based lubricants and fuels. Currently, biodiesel, which is esterified vegetable oil, has found a market niche because its use reduces some noxious exhaust emissions.

Small-scale oil extraction is probably more common in other parts of the world than in the U.S. The book *Small-Scale Food Processing* (1), although written primarily to assist people throughout the "developing world," should be of interest to anyone considering this enterprise.

The book contains a section on vegetable oil that provides an overview of the process and equipment required for extracting oil from various seeds and nuts. The book also includes a "catalog" of equipment with hundreds of manufacturers listed.

Contents:

Oil-containing seeds, nuts, kernels (from IBG Monforts product literature.)		
Apricot stones	Black currant	Red pepper
Avocado	Jojoba	Brazil nut
Cotton seed	Coffee	Passion fruit
Billberry	Cocoa	Pecan
Borage	Coriander	Pistachio
Stinging nettle	Caraway seed	Rape seed
Beech nut	Pumpkin seed	Castor bean
Calendula	Linseed	Sea buckthorn
Cashew nut	Mace	Mustard seed
Copra (dried coconut)	Corn seed	Sesame seed
Safflower	Macadamia nut	Soybean
Groundnut	Almonds	Sunflower seed
Spurge	Melon seed	Tropho plant
Rubber seed	Poppy	Tomato seed
Rose hip	Nutmeg	Grape seed
Hemp	Evening primrose	Walnut
Hazelnut	Neem seed	Citrus seed
Raspberry	Niger seed	
Elderberry	Palm kernel	

Ordering information is included in the **Resources** section below. Another useful publication for anyone who wants to extract oil from seeds with a minimal investment of capital is the manual *Using and Maintaining the Ram Press* (2) published by Enterprise Works Worldwide.

Basic Steps

Raw material preparation

Preparation of the raw material often includes removing husks or seed coats from the seeds, and separating the seeds from the chaff. Information about seed cleaners designed for small-scale operations can often be obtained from agricultural research stations where small

plot research is conducted with various crops. For instance, USDA researchers working with flax in North Dakota purchase some of their equipment from Seedburo (3), which will supply a catalog upon request. Almaco (4) is another company that specializes in equipment for research, such as one- and two-row test plot combines and various types of stationary threshers. Check **Resources** for additional sources of equipment.

Extraction

Oil extraction can be done mechanically with an oil press, expeller, or even with a wooden mortar and pestle—a traditional method that originated in India. Several types of small-scale extractors are commercially available, both imported from other countries and manufactured in the U.S. Oils can also be extracted with solvents, but solvent extraction is a complex operation. Appendix 1 describes and compares various methods of extraction. Appendix 2 presents a chart with additional information about the extraction and refinement of vegetable oils.

Clarification

Clarification removes contaminants, such as fine pulp, water, and resins. Oil can be clarified by allowing it to stand undisturbed for a few days and then removing the upper layer. If further clarification is needed, the oil may be filtered through a plastic funnel fitted with a fine filter cloth. Finally, the oil may be heated to drive off traces of water and destroy any bacteria.

Packaging and storage

Use of clean, dry containers to package and store oils can help to prevent rancidity. Sealed glass or plastic bottles are adequate. It is preferable if they are colored and kept in a dark box. The shelf life of oil can be expected to be 6–12 months if it is adequately packaged and kept away from heat and sunlight (1).

Sunflower Seed Oil Using The Ram Press

Enterprise Works Worldwide (formerly Appropriate Technology International) (5) has supported a number of projects in Africa processing oilseeds using the ram press. The presses are mass-produced in Zimbabwe for export. Over 4,000 presses have been sold since they were initially designed in 1986. The price in Zimbabwe is $80. Each press weighs about 45 pounds and can process 100 to 120 pounds of sunflower seeds per day. The extraction rate is 20 to 25% using the softer-shelled, high-oil-content sunflower varieties. The ram press can also be used for sesame, mustard, and safflower seeds, and peanuts. Details on the use of the press are given in EWW's manual *Using and Maintaining the Ram Press* (2). The information on pressing sunflower seed that follows is from that manual.

Choose seed that has a soft shell and high oil content (40–45% oil). Most high oil content sunflower seeds are all black. Many striped seeds have little oil. To get some idea of how the seed will work in the press, try to crack it open with your fingers. This will not be difficult with soft seed. With hard seed, you may need to use your teeth. Now look at the kernel inside the shell. It should fill the shell completely. If the seed is much smaller than the inside of the shell, it was probably harvested too early. You will not get much oil from it.

Put the kernel (without the shell) between your two thumbnails and squeeze. Did the kernel fall apart? Are there little smudges of oil on your thumbnails? If not, there may not be much oil in the kernel. (This is a very rough way of assessing seed. The manual also presents a more precise method for determining the percent of oil, but encourages the practice of checking seeds with your fingers.) Check the different batches of seed you come across. In time you will get a feel for the differences.

For successful pressing, the seed must be:

- Dry. Moist seed will lead to low yields and clogging of the cage (a part of the press). Moist seed may also get moldy.

- Clean. Fine dust in the seed may clog the cage. Chaff left in the seed will absorb some of the oil and keep it from getting squeezed out of the cage. Sand in the seed will wear the press out. Stones badly damage the piston.

- Warm. Warm seed will yield the most oil for the least effort.

Seed should be dried before being bagged and stored. Very damp seed will feel humid when you bury your hand in it, especially if the seed is warm. If you heat your seed in the sun under a sheet of clear plastic, you may see moisture collecting on the underside of the plastic if the seed is too wet.

Seed that is slightly too damp may feel dry, but will not press well. If it is too damp, but not yet moldy, it can be dried in the sun. (Never press moldy seed. It is not safe for human consumption.) Spread the seed out thinly on the ground or on plastic or roofing tin. At the end of the day, pile the seed up to keep it from absorbing moisture in the cool night air and spread it out again in the morning. If there is any chance of rain or if the morning dew is heavy, you will need to bag all the seed in the evening and put it back out the following morning. After two or more sunny days, the husks will have dried out. Now bag the seed and store for a week. In that time, the moisture in the seed will be drawn into the dry husk and the entire seed will become evenly dry.

Winnowing is a low-cost way to clean the seed. On a day when there is a steady breeze, spread a cloth on the ground. Drop the seeds from a container to the cloth. The chaff and dirt will blow away. The seeds will collect on the cloth. Any stones must be picked out by hand.

If the sun is shining, the seed can be heated on a piece of roofing tin or some black plastic. Spread the seed thinly and evenly on the sheet. On a sunny day it will be hot to the touch in 15 minutes. The seed should be at least 104°F, which is pleasantly warm to the touch. The yield will improve as the seed gets hotter, all the way up to 150°F, uncomfortably hot to the touch. The seed will heat faster on a black surface than on a light-colored surface. Some people also cover the seed with a sheet of clear plastic. This helps to hold heat in and make the seed hotter.

If the sun is not shining, you can also heat the seeds over a heat source. Put the seeds in a shallow pan over low heat for 5 minutes. You will need to stir the seeds often. Be careful not to overheat the seeds on the bottom. Charred seeds will give the oil a bad taste.

Alternatively, you can use a double boiler to make sure that the seeds are not burned. You will need two pots, one large and one smaller. Set the larger pot on a stove or fire with enough water to keep it from boiling dry. Set the smaller pot inside the big pot. The bottom of the small pot does not need to touch the water in the big pot. Put the seed in the smaller pot, stir it occasionally, and the steam from the boiling water will heat the seed without burning it. The seed should be ready in 15 minutes.

The boiler works best if the smaller pot is almost the same size as the big pot. Then there is not too much room for the steam to escape from between the two pots. This method does not require as much attention and stirring and you will not spoil any seed from accidental charring, but it uses more fuel.

The seed is now ready to be pressed. The pressing operation is described in detail in the manual, complete with diagrams. Dr. Rita Laker-Ojok (6), an EWW staff person working in Africa, cautions that training in use of the press is important, especially in regard to pressure adjustments. Correct adjustment allows the "cake", or meal, to come out; too much pressure may cause a jam.

According to Dr. Ojok, the sunflower oil produced is of very high quality. It can be further processed, or clarified, in one of three ways. The simplest is to let it settle for a week. Alternatively, the oil can be mixed with a little water and salt and boiled for 10 minutes. This changes the taste slightly. Or the oil can be filtered through coat lining fabric covering the opening of a pipe fit into the bottom of a bucket.

Seed cake or meal, a valuable by-product

Seed cake is a valuable second product of your pressing business. Sesame seed cake is valuable as a human food. Sunflower seed cake is not suitable as a food for people, but it makes a good addition to chicken, pig, or cattle feed. Since sunflower seed cake has all the seed hulls in it, it is very fibrous. The ram press does not get all the oil out of the cake; it is oilier than most feed additives. It is quite high in crude protein, but contains very little carbohydrate. It should be used as a feed additive, not a feed by itself. The EWW manual describes feed rations for commercial broiler chickens, cows, and pigs that include sunflower seed cake.

Proper storage of both seed and seed cake is extremely important. Seed must be protected from moisture, rodents, and insects. Very moist seed will rot. Even if your seed is not moist enough to rot, it may be moist enough to grow mold. This is a problem for two reasons.

- Moldy seed cake does not taste good to animals. They may not be willing to eat moldy feed.

- Some kinds of mold make mycotoxins such as aflatoxin. These poisons can make people sick or give them cancer. Some of the poisons from moldy seed will end up in the oil, but most remains in the seed cake. Poison in moldy cake can make animals sick. It can also get into the meat, eggs, and especially the milk of the animals that eat the cake.

Mold spores (seeds) are present in all crops. Molds grow best in warm, humid weather. To

prevent the growth of mold, seeds need to be dried before or shortly after harvest. Even dry seed can quickly get damp by being in contact with moisture or damp earth. Once the seed is

dried and bagged, it must be stored carefully to keep it from taking up moisture. The moisture content of the seed should be no higher than 10%. To test for percent moisture, weigh a sample of seed or cake, then heat the sample in an oven at 300°F for 1 hour. Reweigh the sample. The weight lost in the oven is equal to the moisture content of the original sample, and the percent can be calculated: divide the weight lost by the original weight, and multiply by 100.

Other Oil Presses

KOMET Oil Expellers

KOMET Vegetable Oil Expellers are manufactured by IBG Monforts in Germany (7), whose range of products covers small hand-operated as well as industrial machines. According to their product literature, KOMET oil expellers feature a special cold pressing system with a single conveying screw to squeeze the oils from various oil-bearing seeds. The machines operate on a gentle mechanical press principle that does not involve mixing and tearing of the seeds. Vir-tually all oil-bearing seeds, nuts, and kernels can be pressed with the standard equipment without cumbersome adjusting of screws and oil outlet holes.

The vegetable oil produced needs no refining, bleaching, or deodorizing, as long as the natural taste, smell, and color are acceptable. Generally, the sediments in the vegetable oil can be removed by pouring the oil from the collecting vessel into clean glass bottles after a rest of approximately 24 hours after extraction. During this time, all the sediments, dust, and other impurities will have settled down on the bottom of the collecting vessel in the form of a hard cake. In addition, the clean oil may be poured through a paper or textile filter in order to remove the natural slime.

Since the vegetable oil will not reach temperatures higher than approximately 100–120°F, all the vital components will be preserved. Therefore, it is excellently suited for natural nutrition. As long as the oil is stored in dark and cool rooms, it will have a long shelf life.

Preconditioning of the seeds is required prior to the extraction process. Big nuts, kernels, and copra (dried coconut meat) have to be crushed to the particle size of peas on the KOMET Cutting Machine "System CRUSHER".

The sole representative for Monforts equipment for the USA and Canada is E. Peter Mathies (8). Mr. Mathies is an employee of Badger Oil Company, which is majority-owned by the Wisconsin Business Innovation Corporation. He also works with the state to introduce new crops, such as canola, hazelnuts, and caraway, to the area; expand the use of present crops such as sunflower for industrial, cosmetic, nutriceutical, and pharmaceutical markets; and make oil from fruit seeds such as cranberry, raspberry, grape, and blueberry. These seeds, which have been waste products, are now being promoted for the vitamins and antioxidants they contain.

Taby Press

The Taby Press (9) is a screw press manufactured in Sweden. Various models are available for cold pressing rapeseed, linseed, flaxseed, sunflower seed, sesame seed, peanut, groundnuts, mustard seed, poppy seed, cotton seed, jojoba, etc. Bengt Jonsson is the constructor, manufacturer, and seller of the oilpress, and is also a farmer.

Adding Value Adds Costs

Although value-added processing can be a way to increase a farmer's share of the food dollar, adding value doesn't come free. At each step, the farmer is adding more work, buying additional equipment and supplies, and using more energy. Information needs increase. And depending upon the situation, liability insurance may become a must.

A key point to remember is that adding value to any foods by processing increases safety risks due to the increased handling. Therefore, rules and regulations are established by each state to protect the public health. In addition, the FDA regulates products going out of state. Anyone considering processed foods as a value-added business should contact their state health department before proceeding.

Related information from ATTRA

The ATTRA publication *Adding Value to Farm Products: An Overview* introduces the concept of value-added farm products, outlines keys for success, and provides resources for additional information. *Evaluating a Rural Enterprise*, *Alternative Agronomic Crops*, and *Keys to Success in Value-Added Agriculture* present things to consider before diversifying and marketing alternative crops, and sources of additional information.

References:

1) Fellows, Peter and Ann Hampton, editors. 1992. Small-Scale Food Processing: A Guide to Appropriate Equipment. Intermediate Technology Publications. 158 p. (A second edition was published in 2000. See **Resources** section for ordering information.)

2) Herz, Jonathan. 1997. Using and Maintaining the Ram Press. Enterprise Works Worldwide. Washington, D.C. 42 p. (Contact EWW (5) for information on availability.)

3) Seedburo
1022 West Jackson Blvd.
Chicago, IL 60607-2990
Phone: 312-738-3700, 1-800-284-5779
Fax: 312-738-5329
Website: www.seedburo.com

4) ALMACO
99 M Avenue
P. O. Box 296
Nevada, IA 50201; USA
Phone: 515-382-3506
Fax: 515-382-2973
E-mail: sales@almaco.com
Website: www.almaco.com

5) Enterprise Works Worldwide
1331 H Street, NW, Suite 1200
Washington, DC 20005
Phone: 202-293-4600

6) Dr. Rita Laker-Ojok
Enterprise Works Worldwide (address above)
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7) IBG Monforts
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E-mail: info@ibg-monforts.de
Website: www.ibg-monforts.de

8) E. Peter Matthies
1400 South River Street
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Phone: 715-635-2197
Fax: 715-635-7262
E-mail: badgeroil@hotmail.co

9) Skeppsta Maskin AB
Bengt Jonsson
Taeby Skeppsta
SE-70594 Oerebro
Sweden
Phone and fax: +46 19 228005
E-mail: skeppsta.maskin@mbox200.swipnet.se
Website: www.oilpress.com/

Resources:

1. Anon. 1993. Oil Processing. Intermediate Technology Publications. 48 p.

   This book is aimed at volunteers training for food processing projects and their trainers, the non-specialist already involved in projects and seeking specific information on technology choice. Contents include raw materials from which oil can be extracted, methods of oil extraction and processing, description of types of improved technologies, case studies, checklist of questions to ask when planning a project/enterprise, facts and figures on a range of pre-processing and extraction equipment, references, further reading, contacts. $15.00 from:

   Stylus Publications, LLC
   P.O. Box 605
   Herndon, VA 20172-0605
   Tel: 703-661-1581 / 800-232-0223
   Fax: 703-661-1501
   E-mail: Styluspub@aol.com
   Website: http://styluspub.com

2. Anon. 1983. Small Scale Oil Extraction from Groundnuts and Copra. ILO Technica Memorandum No. 5, MF 06-274. 111 p.

   A look at the steps involved in removing oil from peanuts (groundnuts) and dried coconut (copra) using small-scale mechanized equipment, this volume should be helpful in either starting a business or in identifying where in the process technical improvements may be made. "It provides detailed technical and economic information on small-scale oil extraction mills using either small expellers or power ghanis, and processing between 100 tons and 220 tons of materials per year. An economic comparison between these small-scale plants and medium- to large-scale plants is provided." $15.75 plus shipping and handling from:

   VITA Publications
   1600 Wilson Blvd., Suite. 710
   Arlington, VA 22209
   703-276-1800
   E-mail: vita@vita.org
   Website: www.vita.org

3. Boyd, John. 1995. Tools for Agriculture, 3rd edition. VITA Publications. 200 p.

   This new, enlarged edition of a well-known catalog lists over 1,000 manufacturers and suppliers of low-cost agricultural implements. Guidance is provided for selection of 3,000 products, from hand tools to animal-powered and small-engine equipment. Illustrated. $49.50 plus shipping and handling from VITA. (See address above.)

4. Carruthers, Ian and Marc Rodriguez. 1992. Tools for Agriculture: A Buyer's Guide to Appropriate Equipment for Smallholder Farmers, 4th ed. Intermediate Technology Publications, London, GB. 238 p.

   A unique guide to small-scale farming equipment. An expert who sets the available tools against the background of good farming practice introduces each subject. The book analyses why some projects are successful and suggests ways to improve them. $55 from Stylus Publications, LLC. (See contact information above.)

5. ECHO
   17391 Durrance Rd.
   N. Ft. Myers, FL 33917
   Phone: 941-543-3246
   Fax: 941-543-5317
   E-mail: echo@echonet.org
   Website: www.echonet.org

ECHO — *Educational Concerns for Hunger Organization — is a non-profit, Christian organization dedicated to the fight against world hunger. ECHO's Website provides access to resources and services for small farm tropical agriculture from around the globe. ECHO's most popular publications are on-line, and include several about oilseed crops. A for-sale publication ($17.50) is* <u>*The Manual Screw Press for Small-Scale Oil Extraction.*</u>

6. Food Processing Machinery & Supplies Association
   200 Daingerfield Road
   Alexandria, VA 22314-2800
   Phone: 703-684-1080
   Fax: 703-684-1080
   E-mail: info@processfood.com
   Website: www.processfood.com

   FPM&SA is a non-profit trade association founded in 1885 to provide a business link between food and beverage processors and suppliers. The Association is made up of several hundred industry members. It can provide information about sources of all kinds of equipment and supplies. Processfood.com is the association's electronic marketplace.

7. Food Protein Research and Development Center
   Oilseeds Processing Program
   Khee C. Rhee, Director
   Cater-Mattil Hall
   The Texas A&M University System
   College Station, TX 77843-2476
   Phone: 979-845-2741
   Fax: 979-845-2744 fax
   E-mail: kcrhee@tamu.edu

   The mission of the Oilseeds Processing Program is to conduct basic and applied research to help add value to oilseeds and to serve as a technical resource to the oilseeds processing industry.

   The Oilseeds Processing Program has experience with essentially all row crop oilseeds as well as a number of industrial crops. Row crop expertise includes familiar edible oilseeds such as soybeans, cottonseed, corngerm, canola, peanuts, sunflower seed, safflower seed, and flaxseed. Industrial crop expertise includes castor seed, rapeseed, crambe, jojoba, and others in various stages of commercialization. Specific services include:

   - *Pilot plant trials in all aspects of seed preparation, screw pressing and solvent extraction, and meal desolventizing and toasting processes.*
   - *Processing of the oil fraction, including degumming, refining, bleaching, hydrogenation and deodorization.*
   - *Conversion of the meal into vegetable food protein flours, concentrates and isolates, or processing into pelleted or extruded farm animal and aquaculture feeds and pet foods.*
   - *Consultation, on-site process trouble shooting, development of operating and quality control manuals.*
   - *Short courses and customized training.*
   - *Technical assistance in market development of new crops.*
   - *Practical short courses and customized training.*

8. Huntsman, Inc
   2362 Warren Ave.
   Twin Falls, ID 83301
   Phone: 1-888-812-3377
   Fax: 208-733-2240
   E-mail: mail@huntsmaninc.com
   Website: www.huntsmaninc.com

   Huntsman, Inc. supplies used and reconditioned food-processing equipment, including seed cleaners and packaging.

9. Judge, Emma et al. (ed.) 2000. Small-Scale Food Processing, 2nd Ed. Intermediate Technology Publications. 184 p.

   This guide provides development workers and small-scale entrepreneurs with the basic information and advice that they need to set up a small-scale food processing enterprise. Part one considers the food processes that are suitable for different crops including fruit and vegetable products, cereal and pulse-based products, milk and milk products, and meat and fish products. Part two is an annotated directory giving the appropriate equipment needed to process a particular food, an index of manufacturers, the approximate costs, and the names and addresses of manufacturers. The potential uses of equipment are examined and much of the equipment is clearly illustrated.

   In this new edition the main text which guides the reader through the stages of food processing activities has been reorganized and clarified, and the catalog section, listing suppliers in approximately 50 countries, has been completely updated. $55 from:

   Intermediate Technology Publications
   103/105 Southampton Row
   London WC1B 4HH
   UK
   E-mail: itpubs@itpubs.org.uk
   Website: www.oneworld.org

10. Logsdon, Gene. 1977. Small-Scale Grain Raising. Rodale Press, Emmaus, PA. 305 p.

    In addition to covering production of a large number of grains, information is provided on harvesting, storage, grinding and cooking. Out of print, but may be found in a library.

11. Potts, Kathryn H. and Keith Machell. 1995. The Manual Screw Press for Small-Scale Oil Extraction. Intermediate Technology Publications. 72 p.

    This practical handbook describes the full process of oil production with a manual screw press (also known as the bridge press or spindle press.) The process is detailed step by step, including health and safety guidelines, equipment requirements, maintenance procedures, and approaches to sales and marketing. Appendices cover record keeping, financial considerations, and the use of a roller mill to speed up crushing, which is one of the essential preparatory stages for maximum oil production. $17.50 from Stylus Publishing, LLC. (See contact information above.)

12. Producers' Natural Processing
    Purdue Research Park
    1291 Cumberland Ave.
    West Lafayette IN 47906
    Phone: 765-563-3437
    Fax: 765-563-6753
    E-mail: leaderb@pnpi.com (Bob Leader)
    Website: www.pnpi.com

    Although most of the small-sized oil seed presses seem to be manufactured in Europe, Bob Leader of Producers' Natural Processing (PNP) provides connections from around the U.S. on the cold press expeller method of seed oil extraction, which does not use volatile solvents. PNP does not sell equipment, but does have information about where to obtain new and used equipment. There are two PNPs. One is an "S" corporation that is owned by independent press operations around the United States, the other is a "C" corporation. The "C" corporation consists mainly of researchers in gene technology, functional foods, and pharmaceutical products. It does consulting work for food processors (especially in the use of non-solvent ex-

tracted ingredients) and has partnerships with major life science companies, bakeries, and cooperatives. The "S" corporation is a shareholder of the "C" corporation.

13. Richards, Keith and Deborah S. Wechsler. 1996. Making It On the Farm: Increasing Sustainability Through Value-added Processing and Marketing. Southern Sustainable Agriculture Working Group. 40 p.

    This booklet is written for farmers who want to take a bite out of the middlemen by bringing the dollars for processing, packaging, labeling, and marketing home to their farms, and for local community leaders who want to encourage farm-based value-added businesses in their communities. Compiled from interviews with Southern farmers and ranchers who are adding value to their products, it describes some of their practices, discusses 10 keys to success, and includes a list of resources. Although some of the resources listed are in the Southern region, most have counterparts in other states and regions. Cost is $12, payable to SSAWG, and includes shipping and handling. Order from:

    Southern SAWG Publications
    P.O. Box 324
    Elkins, AR 72727

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February 2001

APPENDIX I

TECHNICAL PAPERS

The papers that follow are slightly condensed from two 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 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.

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 James Casten and Dr. Harry E. Snyder

Uses Of Vegetables 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.

Seed	Oil Content (%)	Uses
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

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. *

* *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.

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. Nathan Kessler deals with extraction by solvents in *Understanding Solvent Extraction of Vegetable Oils* in this same series below. 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.

Seed	Fat Content (%)	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

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 can exert up to 100 pounds per square inch.

Since greater pressure provides greater oil recovery, heavy and strong mechanical jacks of several designs (screw jacks, ratchet jacks, and hydraulic jacks) have often replaced the lever. A 20-ton jack can exert 1,000 pounds per square inch on a small cylinder of seeds.

Batch Presses

A batch press 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 presses 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.

Advantages of small batch presses:

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

Disadvantages of small batch presses:

- They are labor intensive.
- 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. 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 is simple in operation. The ground seed 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 continuous screw presses, are used throughout the world for the expression of oil from copra, palm kernels, peanuts, cottonseed, 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.

Advantages of expellers:

- They are the most common type of mechanical extraction equipment in use commercially today.
- They require less labor than any other method.
- Where power is reasonable in cost, and labor is expensive, continuous expellers are economical.
- Plant capacity is higher than with batch equipment.
- Expellers extract a greater proportion of the oil than do hydraulic batch presses.

Disadvantages of expellers:

- Equipment must be purchased.

- 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.
- More energy is required than for batch processing.
- Electric power is required for the press and for auxiliary equipment.
- The press must operate continuously for at least eight hours; intermittent operation is unsatisfactory.
- 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.

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 there is no problem in grinding the seed, it may be left on.

Grinding or rolling

Seed is not usually 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 gums precipitating cause the cloudiness, 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. Heating to drive off all moisture, for the reasons cited previously, should dry the degummed oil.

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.

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.

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.

UNDERSTANDING SOLVENT EXTRACTION OF VEGETABLE OILS

By Nathan Kessler

INTRODUCTION

Oil is extracted from seeds, beans, and nuts for use as cooking or salad oil; as an ingredient in paint, cosmetics, and soap; and even as fuel.

Historically, such oils have been extracted by wrapping seeds in cloth, and then using devices operated by stones and levers to exert pressure on them.

An improved form of mechanical device, which allowed considerably more pressure to be exerted, involves the use of hydraulically operated rams: a simple, hand-operated cylinder pump is used to press flat plates or hollow cages attached to the hydraulic ram against a fixed-position ram.

This type of press developed into a motorized hydraulic pump system that pressed the seed bag and then released a press cake.

The next improvement in extracting oil was the screw press or expeller. Screw presses use an electric motor to rotate a heavy iron shaft, which has flights, or worms built into it to push the seeds through a narrow opening. The pressure of forcing the seed mass through this slot releases part of the oil, which comes out through tiny slits in a metal barrel fitted around the rotating shaft. Expellers have a continuous flow of seed through the machine in contrast to the hydraulic system described above, which uses small, individual packages or batches of seed. To release as much oil as possible, the seeds must be dried to rather low moisture content and exposure to high temperature causes darkening of the oil. It also causes some scorching or overheating of the meal. The meal contains protein which, if undamaged, may be used for either human food, soy flour for example, or animal feed such as soybean meal.

Because most press or expeller processes overheat the meal and leave too much of the high value oil in the seedcakes, methods of extracting the oil with solvents were developed. Seeds (like soybeans) with low oil content are processed by solvent methods alone. In other cases, presses are used first to extract part of

the oil; then solvents extract the oil that remains in the seeds.

Because of their efficiency, processes employing solvents to extract vegetable oils in large quantities are in wide use, and solvent extraction equipment is readily available commercially. The basic technology of solvent extraction is simple, but great care should be taken in deciding whether and where it can be used.

Solvent extraction of vegetable oils, which recovers more oil than earlier methods and leaves more usable meal, begins to be economically attractive where large quantities of seed can be processed (at least 200 tons per day for continuous-feed processes); where storage, transportation, power, water, and solvent supply are adequate; and where occupational safety and training standards can be enforced. There are solvent extraction plants with capacities of up to 4,000 tons per day.

OPERATING PRINCIPLES

Solvent extraction is simple in principle, but complex in operation.

The seed is prepared by being cracked into chips. These chips are warmed and passed through smooth flaking rolls. The flaking rolls flatten the chips into paper-thin, flat flakes. The thin flakes can then be treated with solvent, which dissolves or washes the oil out of them. Solvents that boil at fairly low temperatures (65°C) are used so that the solvent can be readily removed from both the oil and the flakes. Solvent extraction recovers almost all the oil, leaving only one percent or less oil in the flakes.

Unfortunately, most solvents are dangerous to handle, more so than gasoline. They burn or explode very readily. Therefore, the equipment that extracts the oil and removes the solvent must be airtight and leakproof, and all motors and electrical switches, lights, etc. must be specially designed as vapor-explosion-proof. No matches, no smoking, and no cutting torches, welders, grinders, or other heat-producing or spark-producing devices can be permitted where such solvents are used. Careless exposures to sources of fire or sparks (including engines of trucks driven too close to extraction plants) have caused disastrous explosions.

Attempts to find solvents that are not explosive and are economical to use have not yet succeeded. Chlorinated hydrocarbons such as trichloroethylene worked well but were found to create a poisonous by-product in the extracted meal. Solvent extraction plants built in 1950 using trichloroethylene had to be discarded or converted to the commonly used explosive solvent, hexane. Today, all commercial oilseed extraction plants utilize hexane or a similar solvent.

DESIGN VARIATIONS

Like pressing, solvent extraction can be done with equipment that processes the oilseed in batches, or with equipment that processes it continuously. A continuous extractor is not considered economically practical unless it processes at least 200 tons per day.

BATCH SOLVENT EXTRACTION

Batch solvent extraction is likely to be the appropriate method if you plan to process less than 200 tons of seed per day, but enough to yield oil in commercial quantities.

Very few batch plants are in use in the United States today. A batch solvent extraction plant can be as simple as an enclosed steel tank with a false bottom made of screen or metal slats.

The flakes are dropped into the tank, where they lie on the false bottom. The tank inlet is closed, and solvent is pumped into the seed for 10 to 20 minutes; then the drain valve at the bottom (under the false bottom) is opened to complete the extraction.

After the final extract has been fully drained, steam is introduced into the bottom of the extractor. This evaporates the solvent out of the flakes. This combination of steam and solvent is piped as vapor into a condenser that contains water-cooled tubes. The solvent is lighter than water, so it is readily freed of water by standing in a tank from which water is decanted, or overflowed. The flakes now are nearly solvent free, but are wet from the steam treatment. They are conveyed out of the extractor to a steam-heated dryer to reduce the moisture to about 12 percent for best storage quality. Most of the washes, or miscellas, are saved and reused on a later batch. However, fresh, oil-free solvent must be used for the final wash of a batch. And the first, oiliest miscella is pumped to a steam-heated, tubular evaporator, which boils most of the solvent out of the mixture, recovering solvent for reuse. The oil then goes to a vacuum stripper, where it is heated to about 100°C and steamed as it passes down through a series of steel baffles or a column of stoneware rings or saddles. The purpose is to expose every portion of the oil to steam, which is needed to remove the last 5 to 10 percent of the solvent from the oil.

CONTINUOUS SOLVENT EXTRACTION

Continuous extractors use conveyors inside vapor-tight housings. The conveyor may be an endless metal mesh belt or a series of sieve-bottom buckets attached to a traveling chain.

Another style uses vertical columns filled with solvent. Flakes are continuously fed at the top and removed from the bottom by a vertical mass-flow elevator. Fresh solvent enters at the bottom, and oily miscella overflows from the top. Still another style uses a rotating carousel arrangement of the extraction baskets or buckets as in the Rotocel: this French Oil Mill Machinery Company stationary extractor rotates the inlet and outlet assembly above and below stationary sieve-bottom baskets.

In all of these extractors, flaked seeds are conveyed continuously into the extractor through a vapor lock or seal that prevents solvent vapors from escaping out of the extractor into the flake conveyor. The flakes are sprayed or wet with miscella as they enter the extractor, and receive several washes with successively more dilute (less oily) miscella. These miscellas drain down through the flakes and through the sieve bottom or belt into pans, which drain into pumps. The pumps transfer the miscella to the next state, from less oily to more oily flakes. In this continuous counter-current, the oldest solvent miscella (the solvent miscella with the highest oil content), contacts the fresh incoming flakes. The final wash uses oil-free hexane. The flakes are then drained (10 to 15 minutes), and dropped from the belt or the basket into a spent-flake hopper.

From here a mass-flow conveyor lifts the still solvent-wet flakes (containing 35 percent moisture) and delivers them into a desolventizer-toaster. This is a steam-jacketed vessel, usually a vertical set of kettles with gates that allow the flakes to fall from one kettle into the next below while being treated with direct steam. The lower kettles act as dryers to bring the moisture content down to proper levels. Air is drawn to cool the dried hot flakes, either in the lower part of the same vessel or in a separate meal cooler. As in the batch extractor system, the solvent vapors flow to a condenser with water-cooled tubes, and the liquid solvent is separated from the water by decanting.

An older form of desolventizer employs a series of steam-jacketed paddle conveyors to evaporate most of the solvent. The partially desolventized flakes then crop into a larger conveyor, into which direct steam is blown, removing the rest of the solvent. This form of desolventization was improved by using super-heated hexane vapor to quickly remove most of the solvent. This first step is followed by a steam treatment. However, neither of these methods cooks soybean flakes thoroughly enough to eliminate trypsin inhibitors. For this reason, if the flakes are going to be fed to nonruminant animals, a cooking or toasting stage has to be added: the flakes are heated to about 125°C, reducing their moisture to 18 percent or less. When the flakes are intended for human consumption, this step is not necessary, since they will be cooked before being eaten.

Solvent in continuous systems is evaporated and recovered from the miscella in the same way as in batch systems. However, when solvent is removed from the flakes by the desolventizer-toaster method, the hot vapors from the toaster can be used as the heat source in the first-stage miscella evaporator. This results in important energy savings.

For seed very high in oil, such as cottonseed, groundnut or peanut, or sunflower, low-pressure expellers are usually used to remove part of the oil at reduced cost. This is followed by flaking and solvent extraction as described above. This pre-pressing is important in cottonseed also because it reduces the antinutritional gossypol material left in the meal.

FACTORS TO CONSIDER IN PLANNING AN OIL EXTRACTION SYSTEM

Solvent extraction of vegetable oils should be seen as part of a technological and economic system that includes far more than the extraction plant itself. Factors affecting the operation of a solvent extraction plant include: potential markets; nature, timing, size, and reliability of seed and solvent supply; adequacy and reliability of power, water, and transportation, and of maintenance and storage facilities; and ability to find and train personnel and rigorously enforce safety standards. Table 1 gives information about some of these requirements.

SIZE OF OPERATION

The size of the operation is the most important factor in determining which kind of process will be used.

For intermediate-scale operations (operations that process up to 200 tons per day), the choice is between batch solvent extraction and expeller (pressure extraction) systems. Batch solvent extraction systems operate more slowly and less efficiently, are more labor intensive and dangerous, and use greater quantities of solvent than properly designed continuous systems do. Because of these drawbacks,

Table 1. Estimated Requirements for Solvent Extraction of Vegetable Oils, Comparing Batch and Continuous Processing

Inputs required per ton of seed processed	Units	Batch processing	Continuous processing
Steam	kilograms	700	280
Electricity	kilowatt hours	45	55
Water	cubic meters	14	12
Solvent	kilograms	5	4
Labor	person hours	0.8	0.5

Source: Ernesto Bernadini, Batch and Continuous Solvent Extraction, Journal of the American Oil Chemists' Society 53 (Hybe 1976): 278.

expellers are usually preferred for installations too small for continuous solvent systems. However, there are instances when expeller extraction is not suitable for a small operation; in those cases, batch solvent extraction may be the only practical way to proceed.

Continuous solvent extraction should be considered only for systems that will treat 200 tons or more of seed per day.

SITE AND DESIGN

Solvent extraction plants are complex systems that must be carefully engineered for safety because of their special hazards. Because of the danger of explosion, solvent extraction plants need to be located a safe distance away from populous areas, and to be designed by experienced engineers. Installation of a plant without such engineering of details is a dangerous error.

COST

The cost of solvent extraction plants is much higher than the cost of expeller extraction plants, usually about double. However, since a solvent plant recovers a greater proportion of the oil, it may still be the economically wiser choice. For example, solvent extraction should recover about 40 kilograms more oil per ton from dry soybeans than expeller extraction would.

PRODUCT QUALITY

Not only does solvent extraction yield more oil, it avoids the overheating of the oil and meal that often occurs with expeller extraction. Solvent-extracted meal can be toasted to optimum food or feed quality.

PERSONNEL AND SAFETY

It takes less labor but more sophistication to maintain and operate a solvent extraction plant than to maintain and operate an expeller plant. Two people per shift are required for the former, compared to three for the latter. The dangers of solvent explosion make tightly controlled procedures necessary. Workers must be trained to have a wholesome fear of exposure to the solvent and of solvent leakage.

RELIABILITY OF THROUGHPUT

For continuous solvent installations especially, it is essential to be able to depend on a steady throughput. Unscheduled interruptions of production, or discontinuities because of the inability to transport the finished product, for example, mean that seed will pile up somewhere and possibly spoil, especially if storage arrangements are insufficient. Unanticipated interruptions of seed supply may cause buyers of oil and meal to turn to more reliable sources. Both batch solvent and expeller operations are less vulnerable to the effects of such interruptions than continuous solvent operations are.

INTENDED USE OF THE OIL

Since crude oil is usually refined before being used as food, it is necessary to have a crude oil refinery that can handle the volume of oil produced by the extraction plant. Food oil refineries are more complicated to operate and more expensive in equipment costs than solvent extraction plants are. For nonfood uses, such as drying oil, a refinery is not necessary.

GLOSSARY

Expeller: A kind of screw press (see below)

Flakes: Thin, flat pieces of seed or press cake (see below) prepared for solvent treatment.

Flights: Also termed worms--the screw threads in an expeller or screw press.

Miscella: Also termed wash--the liquid, containing oil and solvent, drained after application of solvent to flaked seeds.

Press cake: Seed residue left after pressing.

Screw press: A press that uses a screw to guide and force seeds through a narrow opening.

Trypsin Inhibitors: Enzymes that prevent the breaking down of proteins.

Wash: Also termed miscella. The liquid, containing oil and solvent, drained after application of solvent to flaked seeds.

Worms: In a screw press the screw threads, or flights, that guide and force seeds through a narrow opening.

APPENDIX II

Frontier Herbs is a natural foods cooperative. The chart below contains information about the extraction and refinement of Frontier's vegetable oils from the company's Wholesale Product Catalog.

Less refined oils are best for cosmetic uses such as massage, bath or facial oils because they are nutrient-rich and free of additives. Sediment is common is less refined oils and is considered normal. In cooking, less refined edible oils have maximum flavor and aroma. However, unrefined vegetable oils are fragile, with limited shelf life. Therefore, some degree of refinement is necessary to ensure a usable product. All vegetable oils should be stored in a cool, dark area.

Winterized—A chilling and filtration process that removes heavy, less stable fats and waxes.

Bleached—The oil is treated with compounds such as activated clay to remove substances, including chlorophyll, that can discolor the oil.

Deordorized—Undesirable flavor and odor compounds are removed by aerating the oil with steam.

Filtered—Particles, such as plant cells left in the oil after the extraction process, are removed.

The Electronic version of Small-Scale Oilseed Processing is available at:
HTML
http://www.attra.org/attra-pub/oilseed.html
PDF
http://www.attra.org/attra-pub/oilseed.pdf

Name	Method of Extraction	Method of Refinement
Almond, sweet	Expeller Pressed	Refined, Bleached, Winterized, Deodorized
Apricot Kernel	Expeller Pressed	Refined, Bleached, Winterized, Deodorized
Castor	Expeller Pressed	Filtered
Cocoa Butter	Expeller Pressed	Filtered
Coconut	Expeller Pressed	Bleached, Deodorized
Grapeseed	Solvent Extracted	Refined, Bleached, Deordorized
Jojoba	Expeller Pressed	Filtered
Olive, Extra Virgin	Expeller Pressed	Unrefined
Rosehip Seed	Expeller Pressed	Filtered
Sesame	Expeller Pressed	Unrefined
Shea Butter	Expeller Pressed	Unrefined

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