Small-scale Oilseed Processing Guide

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This guide has been developed by Penn State University Cooperative Extension in the Department of Agricultural and Biological Engineering. It is intended to present the most effective and broadly accepted practices for small-scale oilseed processing in the Northeast. As of the publication of this document, the practices discussed within are current and up to date. This guide is a joint production between Penn State and the University of Vermont. This guide will be made available in PDF form through various websites.

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Published November 27, 2013

Acknowledgements

We would like to acknowledge the growers and oil processors in the Northeast who provided insight into their oilseed processing operations.

This guide was funded with generous help from:

Oilseed Processing in the Northeast

Oilseed crops present an opportunity for farmers in the Northeastern U.S. to diversify their operations and provide a crop typically grown in the Midwestern and Great Plains regions. Many of the crops are adaptable and have been grown in the Northeast; some for a number of years and others only recently. The University of Vermont publication, "Oilseed Production in the Northeast; A Guide for Growers of Sunflower and Canola," provides information on the agronomic aspects of these oilseed crops. This publication extends this information into processing and other considerations for expanding into a small-scale oil extraction industry.

Oilseed crops provide oils with many uses. Oil from many of the crops can be used directly as fuel in vehicles modified to use as straight vegetable oil, or indirectly as fuel when the oil is first transesterified into biodiesel. Some producers have set up systems where the vegetable oil is first used for culinary use, as in a deep fat fryer, then picked up and processed into biodiesel. In this way the oil is used for both food and fuel, satisfying both sides of the food vs. fuel debate. As food systems seek ways of becoming regionalized, vegetable oil production may become a part of this way of thinking and acting.

The majority of the experience leading to this publication has been from the production of canola and sunflower oils, as these are oilseed crops and oils that are produced in quantity for culinary use. While soybean oil is the predominant oil in the United States, those seeking an alternative crop are more likely to look at crops like canola or sunflowers. The University of Vermont and Vermont farmers have been growing and producing oils for a number of years. Penn State first started growing canola as a petroleum diesel fuel replacement and later became interested in the production of edible oils. Both universities have collaborated with farmers and processors to learn what has worked for them in the production of edible oils, and this guide is a culmination of those experiences.

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1.1 Overview of Small Scale Oilseed Pressing

Introduction

Small-scale oilseed processing involves many steps. Despite being simpler than the commercial equivalent, there are a number of important steps that must be taken to make the system effective. From the grain silo, where the seed is stored, to the finished product, this section covers the process that the small-scale producer may employ when processing oil from oilseed.

Grain Silo

After being harvested and cleaned, the seed to be used for processing is placed in the grain silo, where it is stored. Grain silos are kept under specific conditions for storage, such as certain humidity levels; these vary from seed to seed. Since the oilseed press, crucial to the operation, can run 24 hours a day, 7 days a week, the storage unit can be used to store seed for many days of oilseed processing.

Auger

When the seed is needed for processing, it must be moved to the expeller press for oil extraction. The majority of the oilseed processing procedure uses gravity as the feeding system. However, at some point the seeds must be move upwards to the press. One way this is done is by using an auger. An auger is a screw inside a tube; the screw spins and pulls the seed from the bottom of the silo upwards to be fed into the press. A belt conveyor also may be used to convey the seed.

At the top of the auger, the seeds are released. As the seed leaves the auger, a magnet inside the discharge collects ferrous metal debris from the seed (Figure 1.1.1). Examples of this debris are screws that have fallen loose in the machinery, metal filings from the elevator itself, and other metal shards which have escaped the seed cleaning process.

From the auger, the seed falls into a cone that contain high and low switches. These switches sense when the funnel is full or empty beyond a certain point, and turns the auger on

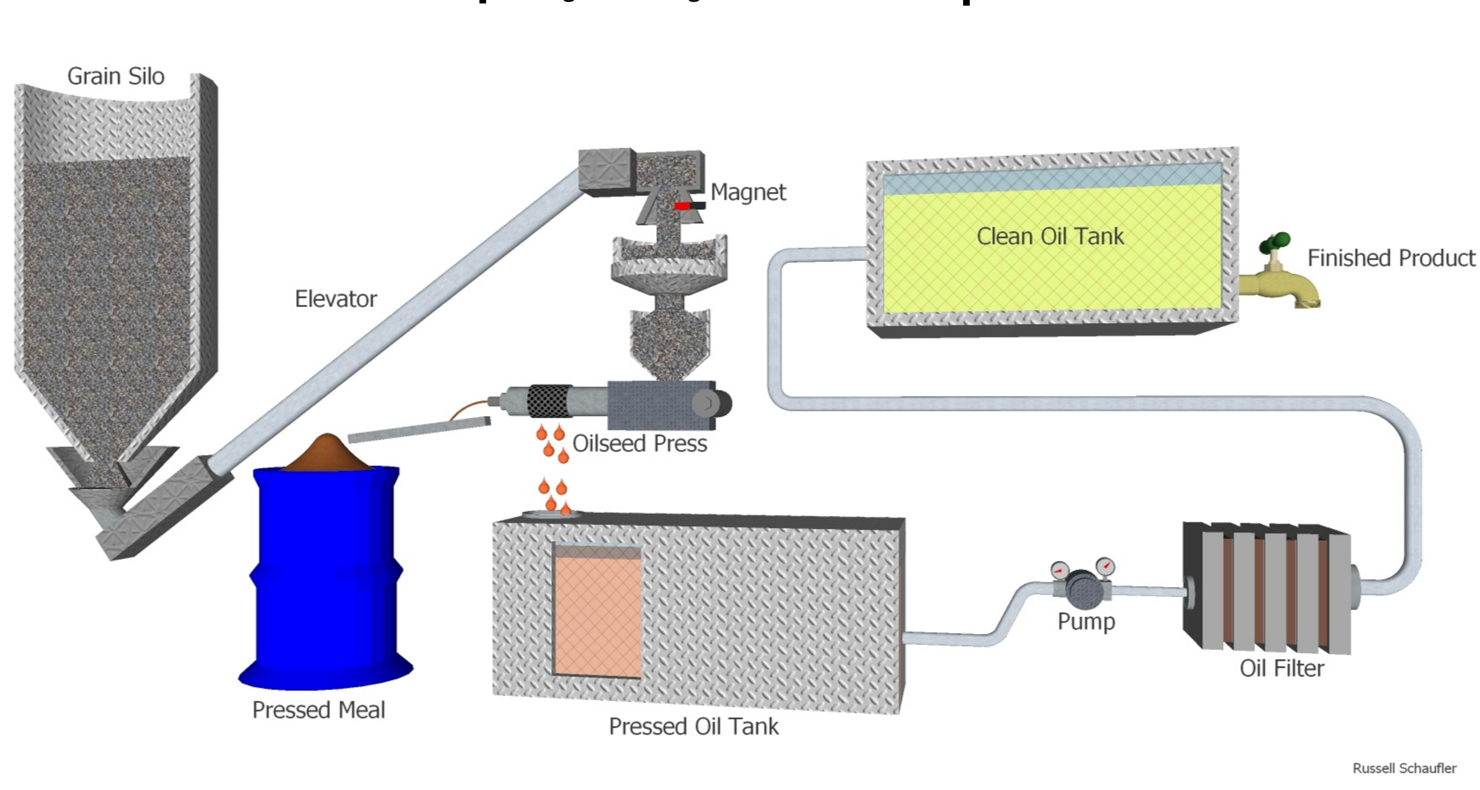


Figure 1.1.1: Ferrous metal debris collected by the magnet located before the press.

and off when necessary to keep the cone full. In this way, the seed feeding into the press does not need to be monitored, as the switch will prevent the feeding system from overflowing. A third "overflow" switch should be used as a safety switch in case the high level switch fails.

Oilseed Press

From the funnel containing the high and low switches, the seed is fed into the hopper on the expeller press (Figure 1.1.2). The press is a crucial part of the system, as it extracts the oil from the seed. An expeller press is composed of several components. From the hopper, the seed is fed into the barrel, in which a screw slowly turns. The screw pulls the seed forward, where it is crushed, squeezing the oil back into the barrel, where it drips from a series of small holes and is collected. The crushed seed is compacted and extruded through the press head, where it is also collected.

The extruded pulp, known as meal, has a variety of uses. Meal is commonly used as feed for livestock, as it is high in protein. It can also be used as pellets in stoves, which burn the meal at high temperature for heating both homes and other buildings. The meal can also be used as organic fertilizer.

Due to its oil content, meal must be used fairly soon after it is collected because the oil in the meal will go rancid over time. The expeller press does not remove all of the oil from the meal; the amount which is extracted depends on the press settings. Expeller presses usually have adjustable tip diameters and a variable speed drive.

Pressed Oil Tank

The oil which is pressed in the expeller press comes out in a steady drip or small stream, and is collected for further processing. Depending on the operation in question, the collection container could be anything from a jug, a 55-gallon drum, to something more complex, such as an oil tank designed for oil storage.

The most effective system collects the oil in a sealed tank. In this case, the oil going from the press to the tank should be covered to prevent outside contaminants from entering the oil.

The tank should be built from a smooth material which will resist

Figure 1.1.2: Small expeller press for extracting oil from seed.

corrosion by the oil. Stainless steel and food-grade plastics are the most common materials. Materials such as copper and aluminum are not desirable.

The oil that has been extracted at this point will contain small bits of debris that escaped the press, called the foots. Foots are suspended in the oil, and are often removed. Different methods are used for removal of the foots. One method involves settling the oil in the tank, allowing the foots to fall to the bottom of the tank.

Some processing systems use a second method of keeping the foots suspended in a stirred tank. The foots are then completely removed in the next process. Either way is effective and often a combination of the two is used.

The Pump

In order to enter the final stages, the oil must be moved from the oil storage tank to the filter, which will finish cleaning the oil. The diaphragm pump is an effective pump design for this process (Figure 1.1.3). Diaphragm pumps work in the same way as the human heart, moving the oil through a series of chambers through valves.

Other pumps which are commonly used are screw-type pumps, which create the flow using a slowly turning screw. Centrifugal pumps are not effective, as the oil moving to the filter must be kept at a constant pressure with very low flow. Pumps are either electrically operated or powered with compressed air.

Figure 1.1.3: A small diaphragm pump.

Figure 1.1.4: An example of a cartridge filter, one common type of filter used in oil filtration.

Filter

The pump from the previous step delivers the oil from the oil storage tank into the filter, the next component in the process. There are a number of different types of filters such as the cartridge filter shown in Figure 1.1.4. A common design used in food and other processing industries is the filter press.

A pump pushes the oil through a

pressurized filter made of a cloth mesh. The filtering agent is usually diatomaceous earth, a fine powder consisting of ground up diatoms. To place the agent into the filter, the diatomaceous earth is mixed with clean oil and pumped through the filter press, depositing the agent on the meshes. The oil to be filtered is pushed through, capturing any foots inside the filter press in the form of "press cake".

The filter press must be cleaned out when full, removing the cake. The clothes are not cleaned with every filtering, and last through many filterings.

Clean Oil Tank

Once filtered, the clean oil is pumped into a clean oil tank. This tank is similar to the pressed oil tank, except it is now only a storage unit. It must be sealed, like the pressed oil tank, to preserve the oil inside. Even when cleaned, the oil contains oxidants which will cause the oil to go rancid after a period of time of exposure to air. For this reason, it is best kept sealed from oxygen.

In some cases, an inert gas such as nitrogen is pumped into the tank, to blanket the oil and keep the oil fresh. In other instances, holding a vacuum in the tank performs the same function.

The oil at this point is ready to be packaged as the final product, or moved on for further processing. Most small-scale processors will bottle the oil at this point.

Summary

The oilseed processing system is a complex and carefully managed procedure. From the storage of the seed, to the extraction of the oil and further cleaning and storage, it is important to maintain and understand the system.

1.2 The Regional Picture

Introduction

In a regional food system, oilseed growth and processing forms a cyclical system. Features of the system are utilized in multiple ways, as discussed here. This system is one example of what can be done using oilseeds in a regional setting.

The Seed

The starting point of the regional oilseed system is the fields. Farmers may grow canola or other oilseed crops as an alternative crop, or as a cover crop. The harvested seed is stored in bins and moved on to the next step of the process, the oilseed press.

After the cleaning process the oilseed press presses the seed, creating two products. The first of these products is the meal. Meal is the remains of the seed after the oil is extracted. Meal is extruded from the tip of the expeller press, and collected, to be used as feed for cattle and other livestock. The meal is high in protein and other nutrients, and makes an excellent addition to the feed ration.

The extracted oil is collected and contained, where it branches out into two uses.

The Uses of Extracted Oil

Oil extracted from the seed has two

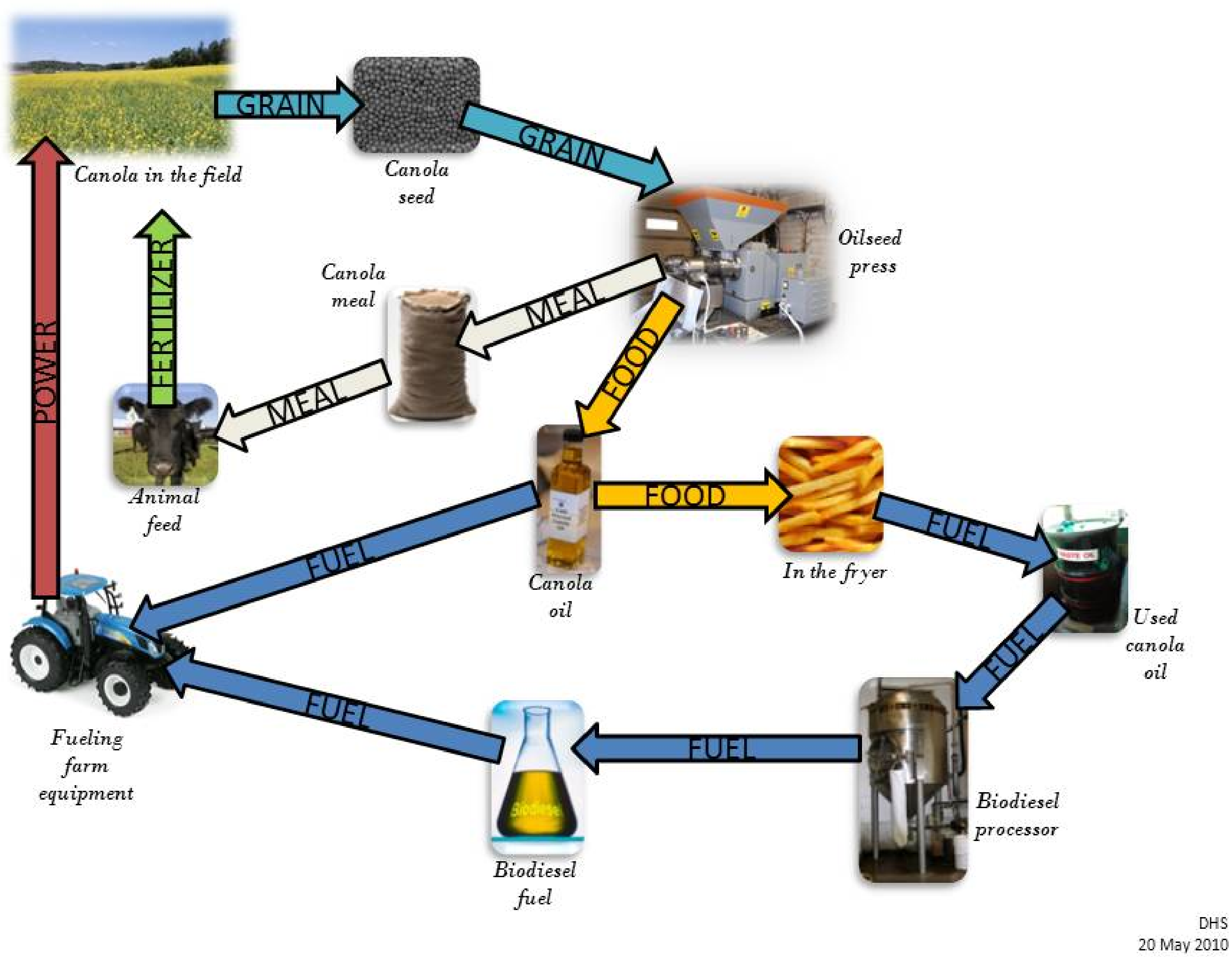


Figure 1.2.1: An example of a tractor run off of a combination of diesel fuel and straight vegetable oil fuels.

options for use. Some of the oil is further refined and bottled for use as edible oil, while a portion is prepared for use as engine fuel. A number of machines can be run on straight vegetable oil (SVO), through the use of modified diesel engines (Figure 1.2.1). The tractors that harvest the canola seed from the fields are designed to use SVO as fuel. This creates a cycle in which the product feeds back into the system that created the product.

The oil which is extracted as food oil is used in the fryers in the preparation of food. The system does not stop at this point. The oil which has been used for frying and cooking is collected as waste vegetable oil, and refined in a biodiesel reactor. This converts the oil into biodiesel, a form of biofuel which can be used in many diesel engines without modification.

Completing the Cycle

As with the oil originally collected for fuel, the refined biodiesel is used in local equipment. This decreases the amount of petroleum fuels needed from the outside, increasing sustainability within the region.

Summary

From the planting of the oilseed and harvesting, to the various uses of the oil extracted from the seed, to the final return of the oil to the origin of the system, a region's oilseed process forms a cycle. Everything that goes into the system is returned, from providing cooking oil to restaurants and meal to cattle and other livestock, to the refining of used oil into biodiesel.

2.1 Processing Edible Oils

Introduction

Edible oils used in the Northeastern United States are primarily sourced from the Midwestern US and Canada. Oils used for salad dressing as well as those used for cooking uses such as deep fat frying and pan frying are all called edible oils. With an interest in locally and regionally produced foods, oils are another food type that can be regionally grown and processed. Sunflower, canola, flax, safflower and other oilseed crops have been successfully grown in the Northeast.

In a typical edible oil processing plant oil is extracted from the seed first using mechanical extraction (expeller press) followed by chemical extraction (hexane extraction). By using both methods less than 1% of the oil is left in the meal that is produced. The majority of this meal is sold for use in animal feed rations.

Components of Edible Oil

Many components are found in a typical vegetable oil (Figure 2.1.1). This figure shows what is in canola oil; other edible oils have varying percentages of the same constituents. Components listed as minor comprise less than 1% of canola oil, yet these parts play a large part in determining the stability, therefore shelf life, of the oil. Many of these minor constituents interact readily with oxygen in the air or other components in the oil to oxidize and form the products associated with rancidity. Other of these minor components are anti-oxidants, working to keep components from reacting with air to form the compounds associated with rancidity. The following list shows some of the minor components and their effect on oxidation. Anti-oxidants resist oxidation so help to preserve the quality of the oil; pro-oxidants promote oxidation so do not help to preserve the oil.

Anti-oxidants: resist rancidity

- Tocopherols (vitamin E)
- Carotenoids

Pro-oxidants: aid rancidity

- Water
- Transition metals (iron, copper)
- Polar lipids
- Chlorophyll

In general it is difficult to find a process that will remove the pro-oxidants without also removing the naturally occurring anti-oxidants. Looking at a label of commercially prepared oil often shows that after processing an anti-oxidant has been added to the processed oil to replace compounds that were removed during processing.

Commercial Edible Oil Processing

The commercial edible oil processing system is usually different from that performed by small-scale edible oil producers. There are steps involved which the small-scale producer would not necessarily need or want to employ with their product. Figure 2.1.2 shows a simplified diagram of commercial oilseed processing.

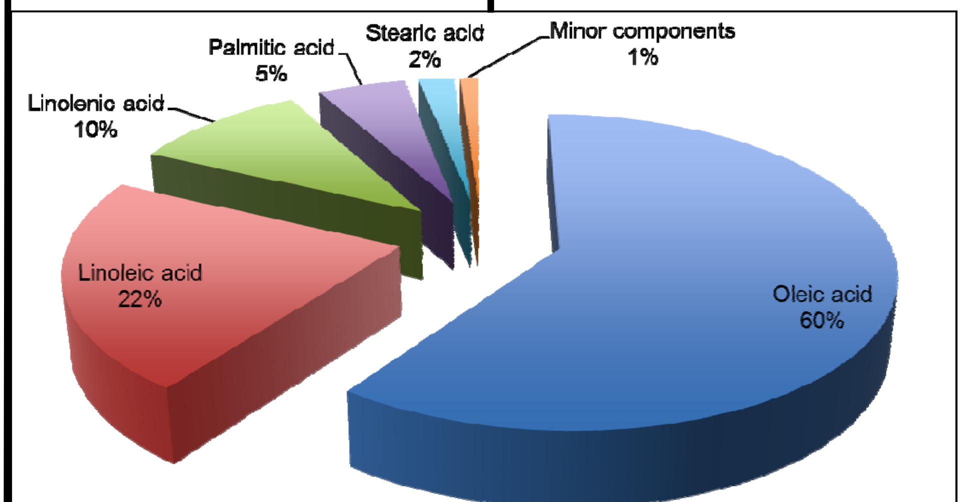


Figure 2.1.1: Components of canola oil.

In this typical method, seed is planted and harvested as with any other crop. This is followed by the cleaning process, which removes unwanted materials such as soil and other seeds from the harvest. In some cases, it is preferable to shell the seed, removing hulls for a better quality final product.

At this point, if the seed is large, the seed is crushed or broken up into smaller pieces. These uniform pieces are then conditioned by heating before being pressed for oil. The two products of this process are the raw pressed oil and the press cake, which is the compressed dry material of the seed.

The raw oil is filtered before moving on to the final steps. The press cake, however, is flaked and broken down for additional oil extraction. The flakes are ground up and mixed with a solvent, often hexane, to produce a slurry, which is heated. During heating, the hexane evaporates, and is collected for further use. While being heated, the meal releases the remaining oil, which is mixed with a small amount of hexane that did not evaporate. The meal is then taken for other uses, such as a portion of the feed for cattle. The oil and hexane mixture is distilled, and the hexane removed and collected.

The remaining oil and the oil from the initial pressing process are bleached using bleaching clay, and deodorized , leaving the oil in its final state which is packaged and sold. This entire process contains several procedures which the small-scale producer may not need or desire for their final product.

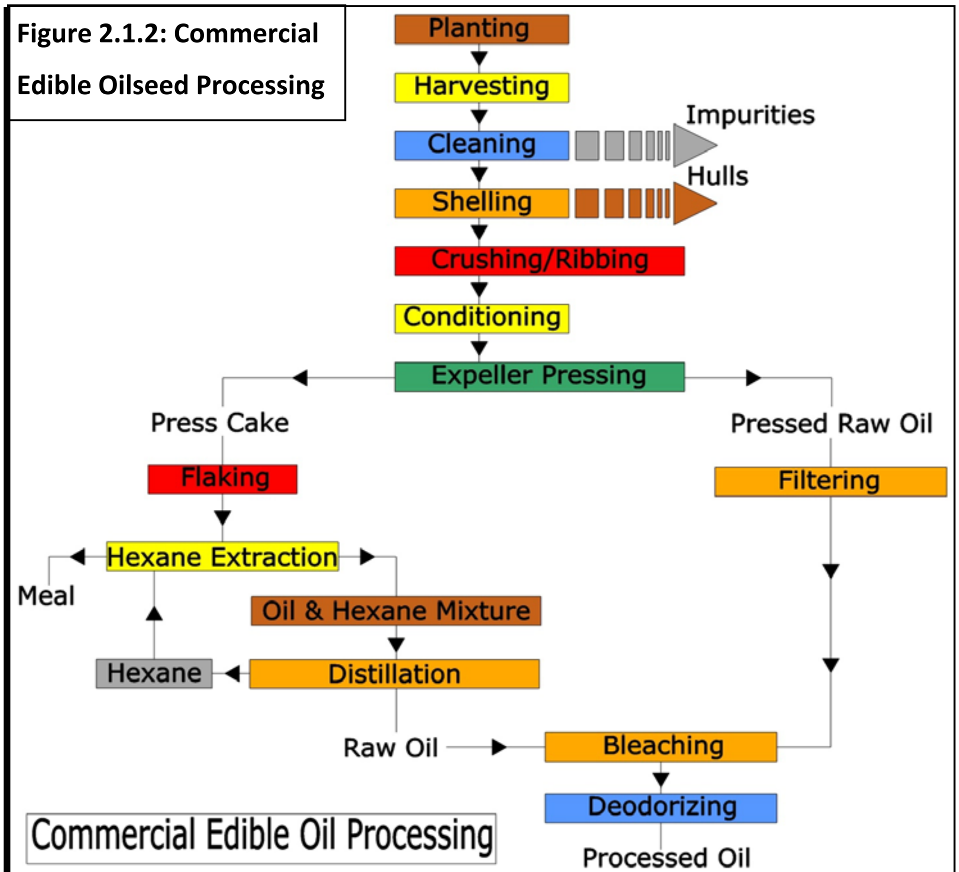


Figure 2.1.2: Commercial Edible Oilseed Processing

Cold Pressed Oils

Small-scale pressing using expeller presses results in more oil being left in the meal than results from chemical processing. Typically, the oil in the meal from small-scale pressing is in the range of 8—15%. Commercial processing leaves less than 1% oil in the meal. While extracting the most oil as possible from the seed is one goal, often producing oil at a temperature less than 49 C (120 °F) is also an important objective. Oil pressed at this temperature below 49 C (120 °F) is known as "cold-pressed" oil and is desired for alleged increased nutritional properties. Cold-pressed oil is also important if the oil is to be used directly as engine fuel because an oil pressed at a lower temperature carries lower levels of phosphorous. High levels of phosphorous in the oil can be harmful to a diesel engine and is one of the compounds with a maximum limit set in the standard for vegetable oil used as engine fuel.

RBD Oils

Edible oils purchased in stores (Figure

2.1.3) are known as “RBD” oils. These are oils that have been Refined, Bleached and Deodorized. Each of these steps is used to create a final oil that is consistent in taste, color and stability. As a result, these oils are generally tasteless, odorless, and colorless regardless of the original oilseed type or quality. While this is

Figure 2.1.3: A bottle of RBD oil from a local grocery store.

the intent of the processing, a locally produced oil may not need to meet the same expectations as the mass-marketed oils.

Small-scale pressed oils that have not been processed or are minimally processed retain flavors and smells common to the original oilseed. For example, sunflower oil that is minimally processed retains a characteristic sunflower flavor and will pass this on to the salad dressing or foods fried in this oil.

For deep fat frying, RBD oils are designed to stand up longer to the long term high heat demanded in these applications.

Processing of edible oils is often broken into the three RBD categories: refining, bleaching and deodorizing. Each of these steps used in large scale processing may be duplicated on a smaller scale. Some are more difficult to implement on a small scale, and may not be justified depending on the market for the end product.

Refining

Refining of oils may include neutralization of fatty acids, removal of phospholipids (a compound containing phosphorous), and filtering of the oil. Other processes may also be carried out to create a more stable oil for subsequent processing. On a small scale, removing hydratable and non-hydratable phospholipids is one goal, while removing particulates through filtration is a second objective. Hydratable compounds are ones that will dissolve in water. Non-hydratable compounds will not dissolve in water,

Figure 2.1.4: A bag of bleaching clay.

and will often settle out or be removed by filtration. There is a small amount of water in edible oils, so water is present to dissolve the hydratable compounds. Refer to Section 2.4 for more information on filtering edible oils.

A simple acid wash of the raw pressed oil will cause many of the hydratable compounds to settle out of the water and become particles that can be settled, centrifuged or filtered from the remaining oil. Citric acid is often chosen as the acid for this operation. In one process, the oil is heated to 80 °C (176 °F). The oil is then mixed in a solution of 2% citric acid, 98% oil. The acid is composed of a solution of 30% acid with 70% water. This total mixture is kept at 80° C (176 °F) for up to 15 minutes, then rapidly cooled, settled, and

Figure 2.1.5: Two different types of bleaching clay. Shown on the left is a sample that is mixed with the oil, heated, and put through a filter press. On the right is a coarser sample that is used as a filter itself, which the oil is passed through. In both cases, the unwanted components in the oil are bonded with the clay, removing them.

separated via centrifuge. Commercial operations may include additional processes in the refining stage.

Bleaching

Oils have a characteristic color when initially pressed. When present on a grocery store shelf, vegetable oils from different seeds have the same nearly colorless appearance. These oils have been bleached to remove the minor constituents that cause the color. Other components, some of them desirable, are also removed during bleaching.

Bleaching removes the oil components that increase the rate of oxidation. When oil is used at high temperatures, for example when pan frying or deep-fat frying, oxidation is accelerated and the oil may develop undesirable characteristics such as off flavor or dark color quickly. Bleaching allows the oil to be used for a longer period of time before these undesirable characteristics occur.

To accomplish bleaching, the oil is mixed with the required amount of bleaching clay (Figures 2.1.4 and 2.1.5). This mixture is heated to a high temperature [90 °C (194 °F) to 110 °C (230 °F)] in the absence of oxygen (air) and mixed. The undesirable (and desirable) compounds in the oil attach themselves to the bleaching clay particles. Filtering or centrifuging removes the clay particles and the compounds attached to the clay, resulting in an oil that has the colorant compounds removed (Figure 2.1.6). Bleaching clay is a type of clay dug primarily in the southern United States. It may be either natural clay or activated with an acid wash. Activated clay will attract and hold more compounds than natural clay. Natural clay is used for bleaching of certified organic oils.

Deodorizing

When pressed, oils contain a variety of components. These include vitamins, fatty acids, protein fragments, traces of pesticides, and occasionally heavy metals, as well as many other materials. The majority of

Figure 2.1.6: Bleached canola oil (left) and unbleached canola oil (right) are very different in color due to the natural colorants removed during bleaching.

these either enhance or detract from the flavor and smell of the oil.

The process of deodorizing removes all of these components from the oil, leaving it flavorless and odorless, essentially the same as other oils which are deodorized. This process involves steaming the oil, which vaporizes the unwanted components and separates them from the desired material. For the small-scale or local producer, this process may not be desired. Deodorizing removes flavor and odors which are often prized in oils, enhancing the flavor of the foods they are used to prepare. Also, this process requires additional equipment which can be costly to purchase, maintain, and operate.

Summary

Edible oil contains a variety of components and features, which all play a part in its refinement and qualities. When commercially processed, edible oil is colorless, odorless, and flavorless, with few of its original qualities.

The small-scale edible oil processing setup contains many of the same features but may leave out steps used in commercial processing, such as bleaching and deodorizing. This allows the oil to retain its original flavor, odor, and coloring. These are often desired traits in locally grown or small-scale oils, as they enhance the foods the oil is used to prepare.

Resources

Vegetable oil processing equipment

Tinytech (www.tinytechindia.com)

Bleaching clays

Oil-dry corporation

http://pure-flo.com/products.html

Introduction to Fats and Oils Technology: Second Edition. AOCS Press, 2000.

Article discussing degumming and acid washes

Acta Chimica Slavaca Vol. 1, No. 1, 2008, 321-328

Northeast Oilseed Information

University of Vermont:

www.uvm.edu/extension/cropsoil/oilseeds

Note: This is not an exhaustive resource list nor do any of the oilseed project partners endorse any of the

2.2 Cleaning and Storage

Introduction

An oilseed press may be the heart of an oilseed pressing operation, but the quality and cleanliness of the seed available for pressing plays a large part in the ability of the press to perform its job. This section focuses on the storage and cleaning of oilseeds that will be pressed for edible oil or fuel. Oilseeds include seeds like canola, sunflower, soybeans, pennycress or other seeds that contain a large enough quantity of oil to warrant the oil extraction.

Oilseeds are stored (Figure 2.2.1) for a period of time before finding their way to the oilseed press. To assure quality oil from the press the seeds going into the press need to be free from foreign objects, weed seed, molds, and other contaminants. Cleaning and storing the oilseeds correctly following harvest will preserve the quality of the seed and preserve that quality through to the finished oil.

Figure 2.2.1: Oilseed stored for immediate processing.

Reasons for storing oilseeds

- Oil stored as seed does not turn rancid, so seed is not pressed until oil is needed
- Oilseed presses are relatively slow compared to harvest speed; seeds need to be stored until pressed
- Different crops come in at different harvest times; one crop may need to be stored while a previous crop is pressed

Reasons for cleaning oilseeds

- Weed seeds present at harvest may interfere with the extraction of oil in the press
- Weed seeds may add unwanted taste or chemicals to the pressed oil
- Dirty seed will wear press & handling components more quickly than clean seed
- Stones or other objects picked up at harvest or during handling will damage pressing equipment

Oilseed Cleaning

Oilseeds should be cleaned either before or following storage and before reaching the press. If a large quantity of foreign material (weed seeds, seed pods, chaff) is present, seeds should be cleaned before storage as the

Figure 2.2.2: Typical seed cleaner

trash contained in the stored pile may be a starting point for molds and heating. Usually time does not permit cleaning all of the seeds before storage, as harvesting and drying equipment commonly can process more volume than cleaning equipment. The seed harvesting operation plays a large part in the cleaning effort needed following harvest. Taking the time to be certain the combine is harvesting the cleanest seed possible is time well spent.

Seed cleaning is often combined with filling bins directly before pressing. As seed is moved from the storage bin to the pressing bin a step in between can include cleaning.

Seed cleaners can be purchased new or used. Seed cleaners have not changed dramatically over the years, and the cleaners of the 1930's look remarkably similar to cleaners built today. Typical seed cleaners are

Figure 2.2.3: An older, but still functional, version of a seed cleaner. When purchasing an older cleaner, resources should be expended to cover belt drives and other hazards.

shown in Figures 2.2.2 and 2.2.3.

Seed cleaners use gravity separation (screens) and air separation (fans) to separate seeds and unwanted material by size and density. Seed screens, sized correctly, can eliminate seed both larger and smaller than the desired seed. Running seed first over a screen sized correctly for the desired seed allows seed the correct size and smaller to fall through the screen, keeping gravel and larger seed out of the desired mixture.

Flowing and shaking this mixture over a screen sized slightly smaller than the desired seed size screens out the smaller seeds, typically weed seeds. Seeds remaining are the desired size, but may still contain weed seeds that are approximately the same size as the desired seed.

A last cleaning step blows air through the sized seed and separates the lighter particles, typically weed seed, from the heavier, desired seed. Winnowing such as this is commonly used to separate the wheat from the chaff during grain harvest.

Farmers have purchased both new and used seed cleaners through dealers or at private sales and auctions. Though the method of cleaning seed has not changed enormously over the years, the enclosure of belt and chain drives and other components has greatly increased the safety of newer machines. If an older machine is purchased time and money should be allocated to enclose belt and chain drives, moving components, and other hazards before using the equipment. Rewiring of an older cleaner will probably be required.

A USDA publication, "Mechanical Seed Cleaning and Handling" describes seed cleaning equipment and recommended seed screen sizes. Although an older publication (1968), many useful tables and descriptions can be found in this manual. Resources such as this are listed at the end of this section.

A seed cleaner will remove off size and density seeds and materials, but will not remove all dust and dirt from seeds. Another component called a dust remover will remove unwanted dust from seeds. This is a component used by only a few oilseed press operators. Those who use it believe that the life of presses, augers and other components will be extended because of the lower abrasiveness of the cleaned seed passing through the press.

Figure 2.2.4: Typical grain bin

Moisture Content of Stored Oilseeds

Oilseeds that will be stored (Figure 2.2.4) need to be kept at a moisture content that does not encourage heating within the seed pile or the growth of molds, bacteria or fungi. Growth of mold or bacteria may make the oil pressed from these seeds unfit for human consumption. The oil may still be tolerable for processing into biofuel, but the handling of moldy or dusty seed presents an airborne respiratory hazard. If the seed is to be sold, contaminated seed will have a lower economic value than good seed.

Figure 2.2.5: Grain moisture tester.

A general rule of thumb recognizes 10% m.c. (moisture content) as being the high end for long term storage. Storing seeds with lower than 10% m.c. should produce good results.

How is Moisture Content Measured?

Moisture content may be measured with the use of a handheld or bench mounted moisture meter (Figure 2.2.5), or calculated using the following method. If available, the use of the moisture meter is much quicker. When no moisture meter is available, following these steps will provide an accurate moisture content of the seed stock.

- Weigh out an amount of seed and record the weight (call this weight W1)
- Place in an open container in an oven at 100 C (212 F) for about 1 hour, stirring occasionally
- Remove from oven and let cool
- Weigh seed again (W2).
- The difference in the weight between W1 and W2 is the weight of the water that has been removed.
- To find the moisture content in percent (%):

$$MC(\%) = \frac{W1 - W2}{W1} \times 100$$

- Example: Weigh out 140 grams (5.0 oz.) of seed (W1). After removal from oven seed weighs 120 grams (4.2 oz.)(W2).

$$MC(\%) = \frac{140 - 120}{140} \times 100 = 14.3\%$$

This seed will need to be dried if it is to be stored and will not press well at this moisture content.

Drying Seed

Most oilseeds harvested will need to be dried to some extent for both storage and pressing. Even when moisture content of the seed is acceptable for storage, most seeds do not press well in the oilseed press unless their moisture content is about 7 – 9 %. Table 2.2.6 shows ideal moisture contents for pressing of various oilseeds.

Table 2.2.6: Ideal oilseed moisture content for pressing

Crop	Moisture Content (%)
Camelina	7-9%
Canola	7-9%
Soybean	9-11%
Sunflower	7-9%

Often this drying is done before storage so handling of the seed is minimized. When dried before storage, seed may be moved directly from the storage bin, through a cleaning process, into the oilseed press.

As with grain, seeds may be dried with ambient air or with heated air. The choice is dependent on the quantity of seed to be dried and the equipment available. Ambient air is the more economical choice if the quantity to be dried is not too great and the time is available to do the drying. If

harvesting a large quantity, hot air drying may be necessary because the seed must be moved through the drying apparatus more quickly to make room for more of the harvest.

Air drying consists of allowing the grain to be in contact with outside air. For a small amount of seed, this can be accomplished by placing the seed in a thin layer outside on a dry day. Larger quantities require a blower mechanism to force air through the seed. This can be done in either a grain bin or with grain aerators (Figure 2.2.7) screwed into the grain stored in a large tote, small bin or small wagon.

Bin and dryer sizing, either forced ambient air or forced heated air, should be done in conjunction with knowledgeable grain bin distributors. Cooperative extension service offices have publications on these systems that can provide information in advance of contacting a distributor, so that you know what questions to ask for the crops you are interested in storing and drying.

Figure 2.2.7: Grain aerator showing (left) the aerator head and screw-in air tube and (right) the aerator head.

There are many variables that affect bin drying, such as depth of seed in the bin, diameter and motor size of drying fan, diameter (size) of seeds, initial moisture content and desired moisture content. Bin floor perforation diameter can make a difference in how a given bin will perform with different seeds. Oilseeds are often small in size, and will fall through the floor perforations of a typical grain bin. Canola, for example, will fall through a grain bin floor used for drying corn, soybeans or wheat. Farmers have used weed blocking cloth or burlap fastened over the floor so that these larger diameter perforated floors may still be used to dry the smaller grains. Replacing the grain bin floor with a floor specifically made for small seeds is another option.

Storage

Long term storage of oilseeds allows seeds to be harvested, stored and pressed for oil as the oil is needed. Stored grains that are at proper moisture content for storage need to be monitored as temperatures and outside moisture affect the storage conditions and quality of the grain. Not paying attention to storage can result in seeds that are not fit for pressing into good quality oil (Figure 2.2.8).

Figure 2.2.8: Mold in canola resulting from condensate formed as temperature lowered.

After seeds have been dried to the proper moisture content for storage, they continue to respire and respond to temperature and moisture conditions in the storage container. As temperatures cool, condensation may form on bin or container surfaces or within the grain itself. These moist areas are prime locations for molds to start growth. For this reason, as outside temperatures cool in the fall the grain and container should be checked each week for condensation, and when moisture is found the grain should be aerated to reduce the temperature of the grain and remove the moisture so no more condensation occurs. When the grain has cooled to winter temperatures the periods between checks may be lengthened. Problems with moisture occur when outside temperatures are dropping in the fall and winter, not as temperatures increase in the spring.

Summary

Proper seed storage and cleaning of seed before pressing are two of the steps affecting the final product. Care throughout the entire process of growing, harvesting, storing, and pressing is necessary to ensure a satisfactory product.

Resources

Seed Cleaning

A.T. Ferrell, Clipper Cleaners
785 South Decker Drive
Bluffton, IN 46714
phone: 800-248-8318
http://atferrell.com/clipper
(Oilseed cleaner company)

Mechanical Seed Cleaning and Handling, Agriculture Handbook No. 354: http://naldc.nal.usda.gov/download/CAT87208718/PDF

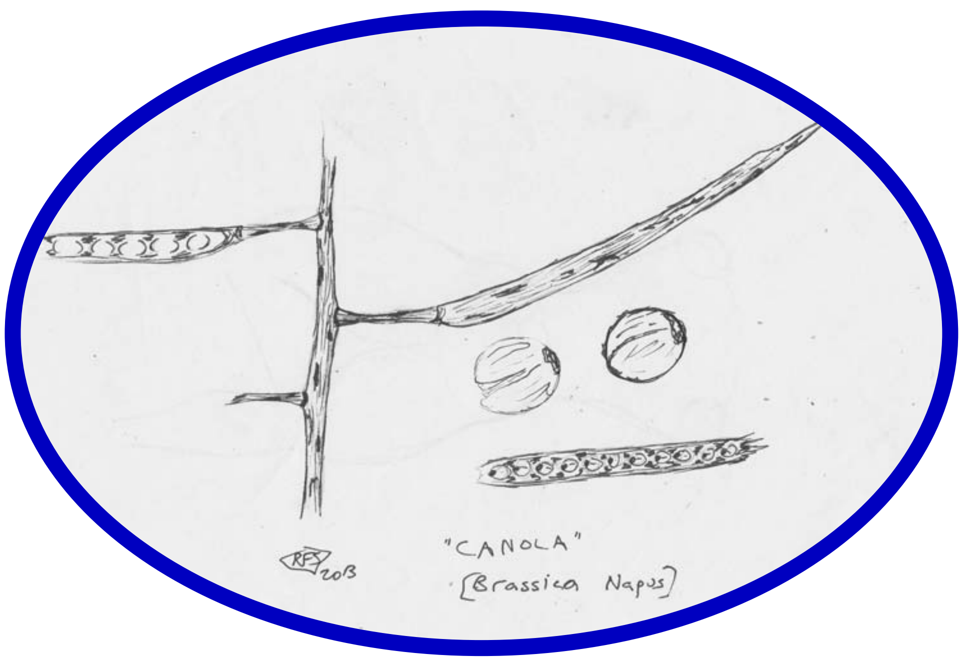
Selecting Fans and Determining Airflow for Crop Drying, Cooling, and Storage. University of Minnesota. 1999.
http://www.extension.umn.edu/distribution/cropsystems/dc5716.html

Storage of Canola, Alberta Agriculture and Rural Development. Revised 2011. http://www1.agric.gov.ab.ca/$department/deptdocs.nsf/all/crop1301

Northeast Oilseed Information

University of Vermont:
www.uvm.edu/extension/cropsoil/oilseeds

Note: This is not an exhaustive resource list nor do any of the oilseed project partners endorse any of the products or companies on this list. It is intended as a resource and starting point for those interested in small-scale oilseed processing.



2.3 Oilseed Presses

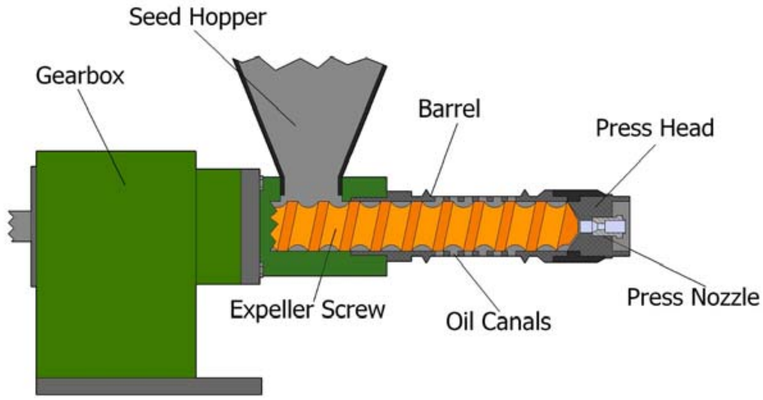


Figure 2.3.2: Expeller Press (screw press) diagram.

Introduction

An oilseed press (Figure 2.3.1) is the heart of an oilseed pressing operation. This section focuses on small oilseed presses used for edible oil production or for producing oil for fuel or biodiesel production. Oilseed presses separate oilseeds such as sunflowers, canola, and soybeans into oil and oilseed meal. Pumpkin or grape seeds and brazil nuts are examples of materials that are less known and can be pressed for their oil in these machines.

Oil from the press is raw oil, and is used either as a food product or as an industrial product. Food products include raw oil in dressings or alone, pan frying applications, or in deep fat frying. Soybean oil (usually called "vegetable oil"), corn oil, sunflower oil, canola oil, peanut oil, and safflower oil are common examples of these edible oils. This large range of oils points to the flexibility necessary in an oilseed press if it is to be used to press oil from a wide variety of seeds and nuts. Some presses offer more flexibility than others, so examine carefully the claims of the press manufacturer before purchasing a press for a particular purpose. If possible, conversations with others who have used a particular press will be valuable.

Figure 2.3.1: Oilseed press.

Vegetable oils typically found in the marketplace are RBD oils. This means that the oils have been Refined, Bleached and Deodorized after the initial removal from the oilseed. Section 2.1, Processing Edible Oils, describes these terms and the procedures that may be used for each process. For a small oil producer, some of these processes may be useful to incorporate into the oil processing line and others may be outside the scope of the operation.

Oilseed Presses

Available small oilseed presses are of two major types; screw or expeller

presses (Figure 2.3.2) or reducing screw/cage presses. Many presses are manufactured overseas while at least one is now available from a United States manufacturer. Information about many of the presses used in the Northeastern United States is being collected and will be available as a separate informational bulletin.

Oil Production

Oilseed presses vary in size and the amount of oil extracted varies between seed types (Figure 2.3.3). As a result, the capacity of an oil seed press is often given in the weight of seeds that can be processed per hour. Depending on the material processed, the expected oil output will vary greatly. For canola, about 1/3 of the seed weight going into the press will be produced in oil, while the remaining 2/3 will be meal. Other seeds will give different oil and meal ratios.

Presses of these types are typically rated in the 3 kg (6.6 lb) to 100 kg (220 lb) of input material per hour range.

Requirements for Effective Oilseed Pressing

Information provided in this section has been gathered from experience and discussions with numerous oil producers and providers of oilseed presses. As experience is gained with a particular press the settings that work best will be determined. Much of this work is on a trial and error basis, and when proper settings are determined they should be recorded so they are saved for reference and as a starting point for the next harvest.

Moisture Content of Seed

For an oilseed press to operate properly, the incoming seed must be clean and of the proper moisture content. Seed cleaning and storage information is provided in Section 2.2: Cleaning and Storage.

Generally 10% is used as a rule of thumb for the moisture content at which to store grain and seeds. While the seed will store well at this moisture content, it most likely will not press well. Seed that is too moist will produce meal that is gummy and will not produce oil as it passes through the press. The moisture in the seed ties up the oil and does not allow the oil and meal to separate as it should.

All seeds have moisture contents at which they press best. A general rule to start from is that the ideal moisture for pressing is in the 7-8% range. Experience shows canola presses best in the 6-8% moisture content range, with other oilseeds requiring similar moisture contents. If the moisture content of the seed being pressed drops too low the temperature of the press head increases when pressing and will make it difficult to stay under the 120F (50C) temperature limit for cold pressed oil if that is important to the operation. Lower moisture content seeds result in higher press temperatures and a lower yield of oil.

Moisture content is often the culprit if

Figure 2.3.3: Examples of oilseeds including (from left to right) camelina, soybeans, and canola.

pressing is difficult. On one occasion, bags of canola at 7% moisture content to be pressed were placed on the floor of the pressing area. When pressing time came a week later, the seed would not press. After numerous failed attempts at getting the press started with this seed, the moisture content was tested again and had dropped to 4%. Unknowingly the seed had been stored directly under a heating vent and had dried considerably by heated air blowing across the bags.

For information on moisture contents for pressing, consult someone familiar with press operation. Often an email or phone call to the press manufacturer will help in getting started on a new type of seed. When an opportunity to press Brazil nuts was presented, an email to the manufacturer delivered the news that the press barrel needed to be heated to about 93° C (200° F) for pressing to work correctly with this high oil content nut. Without this information a great deal of time was used unproductively as various lower temperatures, speeds and tip sizes were unsuccessfully tried.

Seed Quality

Seed quality is also important, as seed harvested either before or after optimal ripeness can impart unwanted flavor or chemical characteristics to the oil produced from that seed. When green (not fully ripened) seed is pressed for oil, the smell it produces when pressed is not the same as the smell of ripe seed being pressed. Oil produced from green seed will not have the characteristics such as smell or taste desired in the finished oil. It is difficult to produce high quality edible oils when starting with low quality seed.

Figure 2.3.4: Properly stored seed (left) as compared to moldy canola seed (right).

Likewise, seed that contains mold from too much moisture during harvest or storage (Figure 2.3.4) will have a noticeable odor and may contain toxins that carry through into the pressed oil.

Pressing Temperature

When reading the ingredients on food, have you noted how vegetable oils are listed? Sometimes oil is listed as “expeller pressed” or “cold-pressed”. Expeller pressed oil means that the oil is extracted from the seed by a press as described in this section. Cold pressed adds an additional requirement that the oil is extracted at a temperature of less than 49° C (120° F). Many people believe that the oil produced at a lower temperature have better health characteristics. Additionally, cold pressed oils have a lower phosphorous level which is required if using the oil as straight vegetable oil (SVO) fuel in an internal combustion engine.

Press Settings

Manufacturers produce presses that have characteristics that can be changed to accommodate different sizes, shapes or types of seeds or nuts. Not all manufacturers accommodate all of the following setting changes, but most allow at least some of the

settings. Remember that the press should be shut off and the power disconnected before changing the settings.

For screw type presses:

- distance between end cap (press head) and screw end
- speed of press
- tip size (diameter of hole through which meal is expelled)
- type of screw (distance between and depth of auger flights)

Considering each of these characteristics in more detail provides the effects of each setting. Because each setting can have an impact on other settings it takes time, record keeping and patience to find the acceptable setting for each type of seed, or even each batch within a type of seed. It is for this reason that operating a press is more of an art than a science. Changes in moisture content or other characteristics may also require changes to press settings for acceptable oil recovery.

Figure 2.3.5: Example of a press head.

Distance Between Press Head and Screw End

The clearance between the end of the screw and the press head itself (Figure 2.3.5) is one common adjustment, though not an adjustment available on all presses. As this clearance is made smaller, the force needed to push the seeds through the press increases, creating a greater pressure overall on the oil/meal mixture. Too much back pressure, though, and the press will no longer allow the meal to pass through, effectively blocking the meal flow and stopping the flow of material through the press. Too large a distance and the meal will pass through easily, leaving a large amount of oil in the meal. Finding the correct setting is a balance between the meal passing reliably through the press and extracting the maximum amount of oil while doing so.

On one type of press, this setting is changed by turning the pressing head in or out. As the head is turned, the threading either increases or decreases the clearance between the end of the screw and the press head. Even a small adjustment (1/16 of a turn) can change the press from being productive to being plugged. Once an adjustment is made it can usually be left for the duration of the pressing of that seed. It is not a setting that needs to be altered continuously.

Turning the press head out to increase clearance looks like an easy process, and usually it is. If the machine has been run for a long period of time, or the heating element has been used on the barrel and head while pressing then turning the press head may be difficult. Turning the press head in can be a trying proposition because meal is already packed into the space between the end of the screw and the press head. Reducing this clearance means squeezing this material tighter, and that's not always easy to do. Removing the press head and clearing the material may be the only way to relieve this pressure enough to be able to turn the press head in.

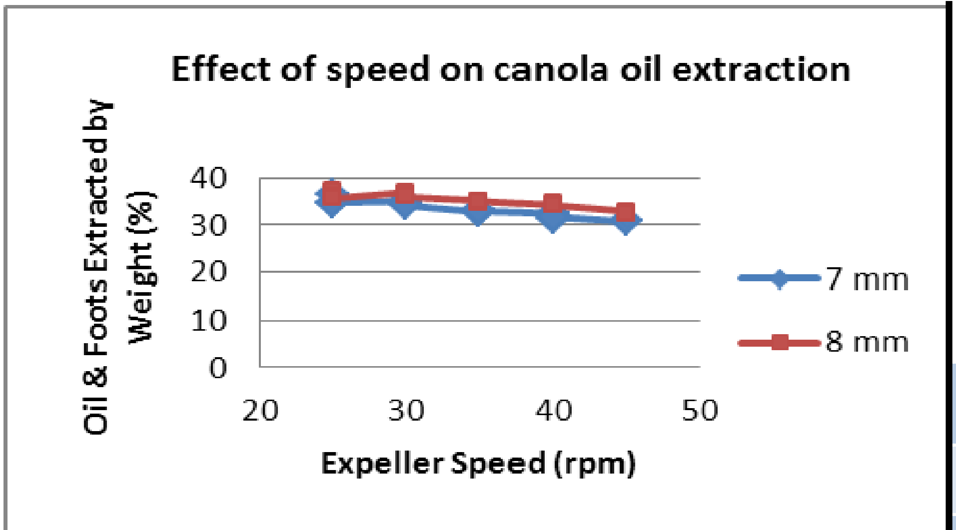


Figure 2.3.6: Effect of speed on oil production.

Speed of Press

Many presses have a variable speed drive. This may be an electronically variable speed drive, a variable pitch drive, or another type of drive that allows the pressing screw(s) to be driven at varying speeds.

Turning the screw(s) faster will put more feedstock through the press in a set amount of time and increase the oil production rate (gallon or liters per hour). This sounds like a great idea, but there are downsides to running the machine faster (Figure 2.3.6). As the screws turn faster, more material is moving through the press and this provides less time for the oil to migrate out and be separated from the meal. As a result, the slower the press is run the higher the extraction rate for oil; the less oil is left in the meal. If cold pressing of the oil is a requirement, then a slower speed is often necessary because as screw speed increases, the temperature of the oil and meal moving through the machine also increases. Temperature and efficiency of oil extraction need to be balanced against overall oil production to decide on a screw speed.

Tip Diameter

Tips are available in varying diameters for each press. Many presses come with a range of tip diameters to allow pressing of different feedstocks. Typically tips are available from ~ 5 mm to ~ 15 mm diameter. Press tip diameter is one factor that greatly influences the amount of "back pressure" on the meal/oil moving through the press. Too large a diameter tip and the feedstock is not held back adequately and flows freely from the press with little oil extraction. Too small a tip and the tip plugs, effectively ending that pressing session. On smaller presses, tip diameter may be the only variable present to change the oil extraction rate, as there may not be a way to change the press head to screw end clearance or the screw speed.

Tip diameters that have been used successfully are presented in Table 2.3.7.

Table 2.3.7: Tip Diameters

Feedstock	Tip Diameter
Brazil nuts	5 mm
Camelina	7 mm
Canola	5, 6, 7 mm
Flax	7 mm
Sunflower (Hulls off)	5, 7 mm
Sunflower (Hulls on)	10 mm

Remember that every batch of seed and every machine are slightly different, so these diameters are a place to start but may not be the best sizes for your feedstock and conditions. Experiment with different tip diameters until the oil extraction rate is acceptable. Also realize that as new tips become worn in, they become smoother and produce less "back pressure" on the meal passing through.

Reducing screw/cage presses use a different technique for pressing the oil than the expeller screw presses. Operational requirements are similar,

Figure 2.3.8: It is important to wait until the press has stopped releasing meal and oil before shutting off the screws. A heating band is shown on the left barrel.

but adjustments are made by tightening (reducing) the distances between the bars to increase the back pressure and increase oil extraction.

Type of Screw

Manufacturers may provide screws with different pitches (distance between high points of the screw) or depths to better handle the variety of seed shapes and types available. For example, one press manufacturer provides a screw that will handle soybeans more readily than the screw that handles canola, camelina and other smaller seeds. Check with the supplier of the press before purchase to be certain you understand the possible need for additional components to handle the range of products you are considering pressing.

Starting the Press

Bear in mind that every press will have slightly different requirements for starting and stopping. Steps below are for one particular type of press, but should translate well to any press with slight modification.

- Be certain the gate allowing seed to the press is shut. This allows the barrel and press head of the press to be heated without seed present.
- Be certain the desired tip diameter is in the press head and set the press head to screw end clearance if a change is needed. Different clearances can be noted by counting the number of threads showing or by measuring this distance.
- Most oilseeds that will be pressed require that the press be initially heated to a temperature of ~120 F (60 C). Typically this is done with heating bands that cover each press head of the press and a controller. Some heat band controllers thermostatically control the heat of the heat band, while other heat bands are simply on or off. Typically about 10 minutes are needed to get the press head up to the preheat temperature. This can be measured with a thermometer inserted into a hole in the press head or more simply with an infrared thermometer aimed at the press head. Some presses do not require preheating.
- Start the press and select the desired drive speed.
- Once the press head is at the correct starting temperature open the gate allowing seed to flow to the press. Oil and meal production is not immediate; it may take several seconds to over a minute to start having oil drip or flow from oil holes in the barrel. Different oilseeds contain different amounts of oil, so the oil

that is produced may range from a steady drip to a steady stream.

Shutting Down the Press

- Close the gate that allows feedstock to flow to the press.
- Wait until the meal flow slows considerably or stops, and oil no longer drips from the barrel (Figure 2.3.8).
- Shut off the screws.
- Turn off heaters if they have been used during pressing.

Manufacturers suggest removing and cleaning the barrels and screws of the presses after shutting down the press. Experience has shown that if the seed flow to the press is shut off and the press is run long enough to expel the material in the press, this may not be necessary. If the press is to be restarted soon (within a week?) then leaving the press without removing the barrel and cleaning is all right. The press will start up again with only the steps outlined above.

Summary

As the center point of the oilseed conversion process, the press can be used to extract oil from a variety of seeds. The quality of the product is determined by many factors, including the settings of the press, as well as moisture content and proper storage of the oilseed.

Resources

Press manufacturers (not an exhaustive listing)

Ag Oil Press (www.agoilpress.com)
Egon Keller (www.keller-kek.de)
Kern Kraft (www.oelpresse.de)
Komet (www.ibg-monforts.com)
Piteba (www.piteba.com)
Tabypressen (www.oilpress.com)
Tokul (www.tokultarim.com)

Vegetable oil processing equipment

Tinytech (www.tinytechindia.com)

Northeast Oilseed Information

University of Vermont:
www.uvm.edu/extension/cropsoil/oilseeds

Note: This is not an exhaustive resource list nor do any of the oilseed project partners endorse any of the products or companies on this list. It is intended as a resource and starting point for those interested in small-scale oilseed processing.

2.4 Oil Filtration

Introduction

As oilseeds are pressed to separate the oil and meal, particles of the crushed seed are also carried into the oil. While the pressing operation can be modified to reduce the amount of particles in the oil, some cleaning of the oil will be needed to remove these potentially unwanted particles. If used for fuel, particles are nuisances as they clog fuel filters and stop the flow of fuel to the engine (Figure 2.4.1). As an edible oil, some operators believe that particles in the oil show that the oil is "natural" or locally produced. Other edible oil producers believe that the product should match "store bought" vegetable oil and should not contain any particles or sediment in the container.

In oil language, the "foots" are the materials removed when cleaning the oil. Oilseed meal and oil are separated during the pressing process, followed by separation of oil and foots during filtration.

Figure 2.4.1: Result of using SVO fuel without reliable filtering: clogged fuel filters.

Filtering of oil can be done in different ways depending on the cleanliness of oil desired as the final product. Four of the most common filtering methods are:

- Settling
- Bag filters
- Cartridge filters
- Filter press

Settling

The least expensive and simplest filtering is done by settling the particles out of the oil. Settling may be done after the oil is pressed as a separate step, or it may be on-going as oil is collected from the press. Some press operators continually stir the oil coming from the press and do not allow settling to occur in the collection tank. When sediment is collected in the tank, at some point the tank must be emptied so that the sediment can be removed. By gently agitating the oil and keeping particles in suspension, the tank does not accumulate this sediment and does not require occasional cleaning. All of the sediment is removed during filtration.

After a period of settling time when the oil is considered "clean" the oil is siphoned, drained, or pumped from the tank leaving the residue behind on the bottom of the container (Figure 2.4.2 & 2.4.3). Different operators settle oil from a few days to a few weeks; it all depends on what size particle is expected to be removed by settling. Small particles will remain in suspension for a longer time than larger particles, so the longer the oil settles the smaller the particles are that are left in the oil.

1 micron is equal to 1/1,000 of a millimeter. There are 25,400 microns in 1 inch. A human hair measures about 11 microns thick, while red blood cells are 7 microns.

While filtering in this way is inexpensive and relatively simple, it does not do as complete a filtering job as mechanical filtering. Farmers who

Figure 2.4.2: 100 milliliters of canola oil collected at pressing time shows about 7 milliliters of sediment after 1 week of settling at room temperature.

Figure 2.4.3: In this tank pressed oil flows slowly from left to right. The oil passes across two partitions, allowing particles time to settle. Most of the settling occurs within the first partition.

use settling as their only method of filtering and use the oil as fuel with no further processing find that fuel filters on their equipment still clog earlier than when fueling with diesel fuel. This indicates that particles remain in the settled oil and that additional filtering should be done to provide a clean engine fuel. As a guideline, engine fuel filters used in agricultural equipment are nominally rated at 12—14 microns, so if a fuel filter is plugging relatively quickly it means that particles at least this large are still suspended in the oil.

If the oil is used as a food product, the particulates remaining in the oil may be acceptable and add to the "natural" oil appeal.

Effect of temperature

As with most processes involving oils, a warmer temperature will aid in settling. As the oil is warmed and the thickness (viscosity) of the oil decreases, the particulates will drop more quickly to the bottom of the oil container. Settling of particles will occur faster when the oil is warmed. Filtering through a cartridge, bag or filter press will occur more quickly when the oil is warmed. A precautionary note is, however, that warming the oil also causes more rapid degradation of the oil through oxidation, a process that leads to oil rancidity. If the oil is warmed significantly it should be covered with an inert gas such as nitrogen to reduce the occurrence of oxidation.

How well does a filter work?

People are often surprised to learn that a filter does not capture all of the particles larger than the rating of the filter as they pass through the filter. For example, many filter catalogs refer to a nominal rating or an efficiency rating for their filters. Often filter ratings are referred to as a "nominal" rating, meaning the filter will remove most, but not all, of the particles over a particular size. An "absolute" rating of a filter means that the filter will remove all of the particles above a particular size. One example is a manufacturer that rates filters as 80% efficient, meaning that a 15 micron rating captures at least 80% of the particles larger than 15 microns while up to 20% of those particles will pass through the filter. Expect to pay more for a filter rated as absolute.

Bag filter

A bag filter (Figure 2.4.4 & 2.4.5) is just as it sounds, a bag of a certain

Figure 2.4.4: Three bag filters and housings arranged in series.

Figure 2.4.5: Bag filter without housing.

porosity material that passes fluid through the bag and captures the particles inside of the bag. One of the simplest and not recommended forms of the bag filter is a pair of old blue jeans with the legs tied off at the bottom.

Bag filters are usually used in conjunction with a bag filter housing, a metal or plastic container that holds the filter. In this way the filter bag is given some rigidity in use.

A difference in pressure is needed to move oil from inside the bag, through the filter material, to the outside of the bag and on to a clean oil container. In general, bag filters work under relatively low pressure. If the pressure becomes too great on the inside of the bag, particles are forced through the bag as well as the oil being cleaned. This defeats the purpose of filtering, so keeping the pressure within the limits suggested by the manufacturer is a good idea. Bag filters are great for liquids like water which is very thin, but for thicker liquids like vegetable oil they may not be the best solution.

As the filter bag collects particles from the oil, it becomes more difficult to push the oil through the filter. A pressure gauge is necessary to know when a maximum pressure has been reached, indicating the need to change the filter bag. The used bag is discarded, and a new bag is installed.

People who use bag filters often install a series of filters. The first filter may take out 25 micron and larger particles, the next filter will remove 10 micron particles and the last filter removes 5 micron particles. In this way particle collection is staggered and bags do not need to be changed as often. Bag filters are not inexpensive, and with the discarding of the bag each time it is used it will be an expensive option if a large amount of oil is to be cleaned.

Figure 2.4.6: End (left) and full (right) view of wound cartridge filter.

Cartridge filter

Where a bag filter has only one layer of filtering material, a cartridge filter (Figure 2.4.6) is a depth filter, meaning that the filtered fluid must make its way through many layers of filtering material. Along the way there are many places for particles to be caught and held, thus cleaning the oil.

Figure 2.4.7: Cartridge filter with clear housing used as final filter for fueling with straight vegetable oil.

Like the bag filter, a cartridge filter fits inside a housing (Figure 2.4.7). The housing may be see through for monitoring the color of the cartridge; as the cartridge catches more particles it becomes darker giving an idea of the life left. The only sure way of knowing how close to the end of its life the cartridge is getting is to install a pressure gauge to monitor the upstream pressure of the filter. As the

Figure 2.4.8: Filter press; a series of filtering plates are pressed together by a manual screw or by hydraulic pressure.

filter catches more particles, the pressure will rise as it becomes more difficult to push the oil through the filter. Again, manufacturers will give guidelines of how high the pressure is allowed to get before changing out the cartridge.

Cartridges are not serviceable and are discarded after use. If large amounts of oil are to be filtered, this will be an expensive filtration method over time.

Filter press

A filter press (Figure 2.4.8) is a type of filter used in filtering liquids in food processing and other systems. Apple juice is one liquid that uses a filter press for cleaning the final product. Because the relatively inexpensive filtering media is the only part discarded after use, it may be the most inexpensive filtering system over the lifetime of the equipment.

A filter press is made up of a number of plates, each of which is covered with a porous fabric. This cloth is covered with a thin layer of filtering media that becomes the actual filter. The clogging of fuel filters and resulting reduction of fuel to the engine was too common before some operators started using a filter press. Following the adoption of the filter press for cleaning the oil no more fuel filters were clogged, indicating the achievement of a higher level of cleanliness.

How to use a filter press

The use of a filter press is a bit mysterious at first. Once the workings of the filter press are understood, this filtration method is the most reliable of the filtration types. Filtration down to 1 micron is possible on a regular basis.

To prepare the filter press for filtering, a mixture of clean vegetable oil and the filter media (a very fine material that acts as the filter) is pumped quickly into the stack of plates that are pressed tightly together. This mixture of oil and media deposits the media onto the face of the cloth covered plates as the oil passes through, creating a buildup about 1/16 of an inch thick on the filtering side of each plate. This media now covers the fabric and becomes the filter; the plates and clothes are re-used numerous times while the media and captured particles are discarded when the filter is no longer passing oil from the dirty side to the clean side (Figure 2.4.9).

To make the clean oil and filter media mixture, the correct quantity of clean oil needs to be saved each time oil is filtered so that it can be used in the next filtering cycle. An auger type paint mixer driven by an electric drill is useful for mixing the oil with the filtering media. This mixture must be pumped quickly into the cavities of the filter plates so that the media is deposited evenly on the faces of the plates. If the mixture is pumped slowly into the cavities, then the cavities between the plates never fill to the top and media is not deposited evenly across the plate surface. For this reason, the pump on a filter press may seem larger than necessary. The pump is sized to fill the filter press quickly, then reduces the amount of oil pumped when oil is actually being filtered.

A filter press pump holds constant pressure on the oil/sediment slurry that is going through the filtering

Figure 2.4.9: Block of foots collected from between two filter press plates. The yellowish colored material is filtering media coating (diatomaceous earth) initially placed on filter plate cloth while the dark colored materials are the foots collected.

Figure 2.4.10: Air operated diaphragm pump on filter press.

process. As sediment builds on the filter plates and media, the pressure on the oil is raised in steps until a maximum pressure is reached. As flow slows at a particular pressure, the pressure is stepped up and flow increases. Any method of holding pressure is acceptable.

A common setup includes an air-operated diaphragm pump (Figure 2.4.10) that is able to quickly pump the initial oil and media mixture into the plate cavities, and then holds pressure as oil is pushed through the media. A source of compressed air is needed if this type of pump is used.

Another setup uses an electrically driven screw pump (Figure 2.4.11) with a pressure switch and accumulator. The pump runs and builds pressure in the accumulator to a high point, then a pressure switch turns the pump off. Pressure in the accumulator and oil being filtered slowly falls off as clean oil is pushed through the filter plate. When a low pressure is reached, a pressure switch turns on the electric pump again and builds pressure back to the high point when the pump shuts off. This cycle continues as oil is pushed through the media and filter plates.

Filtering media

A common filtering media is diatomaceous earth (DE) (Figure 2.4.12). This filtering material is used

Figure 2.4.11: Electric screw pump for filter press.

in swimming pool filters and various food processing applications like the cleaning of apple juice. In food processing terms it is considered GRAS (Generally Regarded As Safe) for filtering. Some processors add other agents to the DE to capture specific particles that they want to remove from the oil as it passes through the filter.

How much oil/media to use

A rule of thumb exists to find the amount of filter media to use. For a typical 1/16 inch buildup on the plates use ~0.15 pounds (68 grams) of DE per square foot (0.09 sq. meter) of filtering cloth area. As an example, for a press that has 12 plates with each plate measuring 10 inches by 10 inches find the DE needed as follows.

1. Each end plate has one filtering surface and all other plates have two filtering surfaces. In this example there is a single face plate on each end; the remaining plates are double faced. This is a total of 22 faces.
2. Each face is 10”x10” for a total of

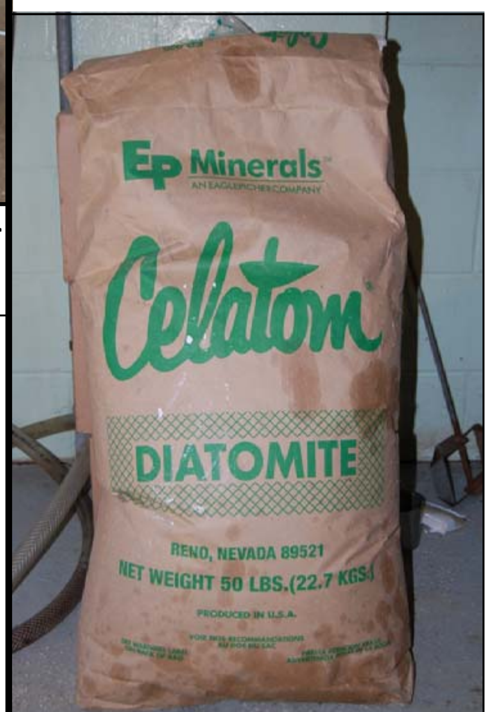


Figure 2.4.12: 50 pound bag of diatomaceous earth (DE). For this vendor designation FW-14 works well for filtering vegetable oil.

100 square inches. 22 faces x 100 sq. inches/ face is a total of 2,200 sq. inches for the press.

3. There are 144 sq. inches per sq. foot. 2,200 sq. inches/144 sq. inches/sq. ft. = 15.3 sq. ft on this press.
4. 15.3 sq. ft. x 0.15 lb DE per sq. ft. = 2.3 lb of DE for this press.

How much oil to use is determined by the volume of oil held by the press. Often this is provided by the press manufacturer in the specifications. Slightly more volume of clean oil should be mixed with the required amount of diatomaceous earth. This mixture of clean oil and DE is circulated quickly through the filter press until all of the DE is deposited on the press plates. At this point incoming oil is switched to the oil to be cleaned. It is important to not let pressure drop to zero inside the filter press when switching from one source of oil to another. If pressure drops inside the filter press it is possible for the filtering media that has been deposited on the cloths to slough off and drop to the bottom of the filter press cavity.

Why use filter media

If used alone, cloths (Figure 2.4.13) used in the filter press will only act as a surface filter. As foots are deposited directly on these cloths, the foots quickly fill the available filtering spots. Once these holes are filled, no more oil will pass through the filter. This is called blinding the filter and will occur in seconds if filtering vegetable oil without the use of filter media.

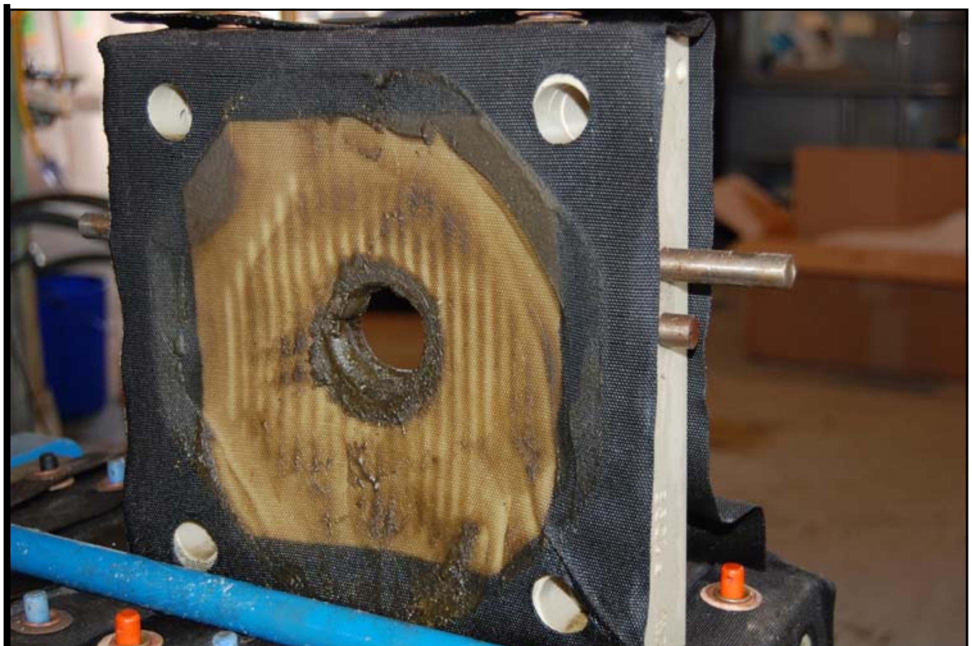


Figure 2.4.13: A cloth from a filter press, with residue from filtering. The residue contains both filtering media and foots.

When cloths become blinded they may be washed gently with a pressure washer. Vigorous pressure washing will result in enlarging the holes present in the cloths and will render the cloths unusable. Filter press cloths taken good care of will last a number of years.

Extending the filtering time

Adding filtering media to the bulk of the oil being processed before it passes through the filter press increases the amount of time that the filter press operates before cleaning. Ideally, the cavity between press plates fills just as the pressure reaches the maximum for filtering as suggested by the manufacturer.

Sometimes while filtering the filtering media stops allowing oil through before the cavity fills with foots. Adding and mixing in a small amount of DE to the bulk oil being filtered increases the length of time that filtering occurs. The additional DE keeps pathways open through the foots as they build on the filter cloths, allowing more oil to be filtered before cleaning. The amount of media to add is found by trial and error as it depends on the amount and size of the foots in the oil.

Summary

Filtration of the pressed oil is necessary if used as fuel, and desirable for improved appearance if

used as edible oil. Settling is a good first step in filtration, but does not provide a cleanliness standard needed for fuel use. Filter presses have been found to be the most reliable method of cleaning oils.

Resources

Filter Press Sources

Ag Oil Press (www.agoilpress.com)
Egon Keller (www.keller-kek.de)
Kern Kraft (www.oelpresse.de)
Komet (www.ibg-monforts.com)
Met-Chem used processing equipment (http://www.metchem.com/index.htm)
Wesco used processing equipment (http://www.wescoequip.com/usedfilterpress.html)
Nebraska screw press (http://www.nebraskascrewpress.com/index.html)

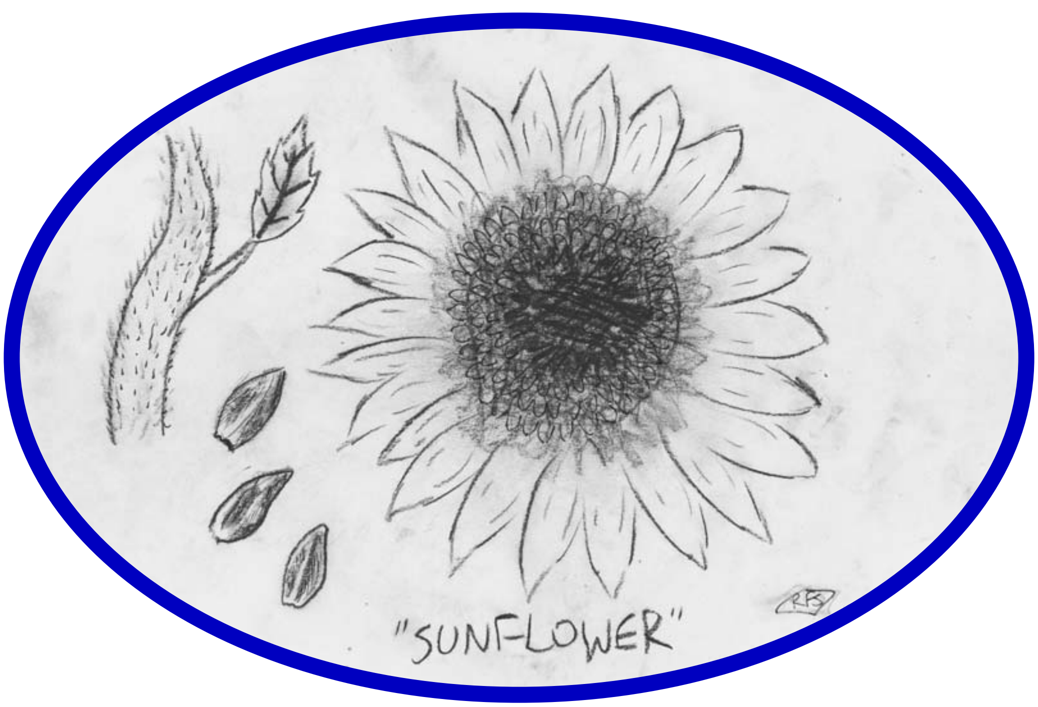
Vegetable oil processing equipment

Tinytech (www.tinytechindia.com)

Northeast Oilseed Information

University of Vermont: www.uvm.edu/extension/cropsoil/oilseeds

Note: This is not an exhaustive resource list nor do any of the oilseed project partners endorse any of the products or companies on this list. It is intended as a resource and starting point for those interested in small-scale oilseed processing.



2.5 Processing Regulations

Introduction

Are you considering producing edible oils for public consumption as a small-scale oilseed processor? The main focus of this section is to present the regulations and requirements in terms of safety and sanitation for small-scale producers who would like to process edible oils from oilseed.

Reasons for Cleanliness

There are many reasons why the regulations currently in place are important. Since the oils produced are for general consumption, they need to meet the expectations of food production found in any food industry. Diseases and harmful materials, if not protected against, can contaminate the product and endanger the health of customers. As well as giving an operation a bad name in the industry, this can also cause a variety of legal problems which may end in fines or other legal consequences.

This section details the different aspects of cleanliness in the workplace when it comes to the processing of edible oils, such as:

- Workplace surfaces
- Personal cleanliness
- Permitted construction materials

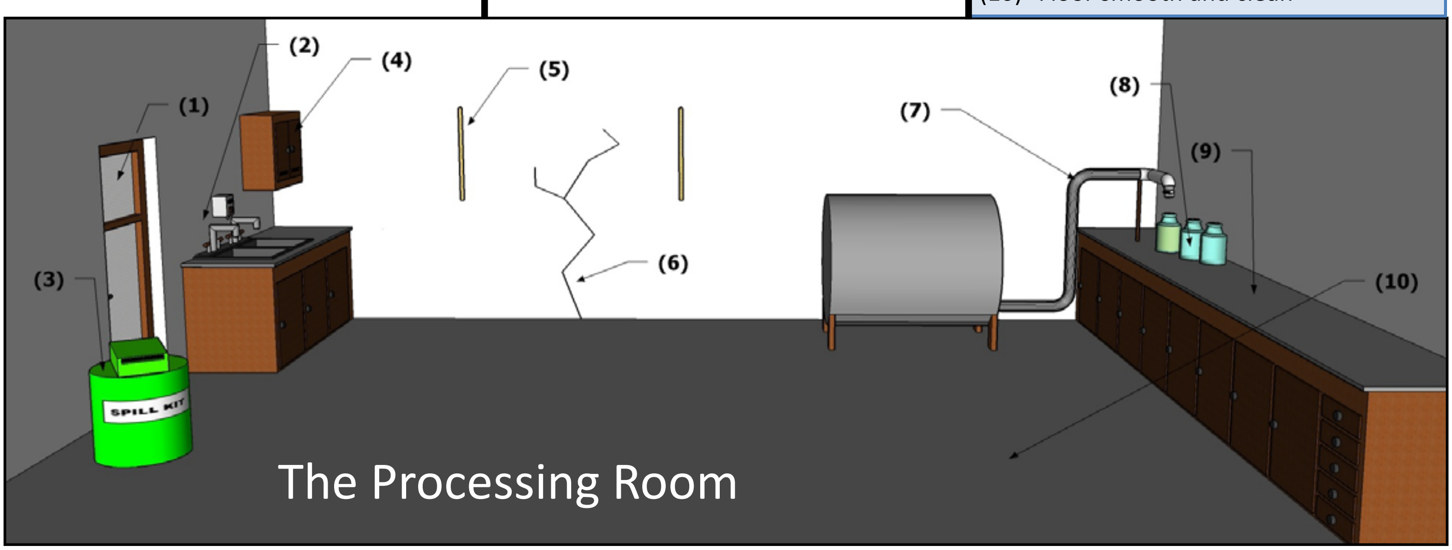
Production Area Requirements

When determining the best location for the production area , size is an important factor. The production area should be big enough to have plenty of space for the equipment and materials. It should also be spacious enough to allow for ease of cleaning resulting in a sanitary operation. Equipment and material placement should be unobstructed and allow for safe movement around the area.

The floors, ceilings, and walls should be constructed of smooth surfaces which are easy to clean, and should be kept clean and in good condition. Any surfaces in contact with the product should be smooth as well, and resistant to decay from normal processing and cleaning procedures.

To prevent accidents involving glass objects, it is important to protect any and all glass objects such as windows, lighting, and bottles. Replace as many of these objects as possible with

Processing Room Legend	
(1)	Door with screen to prevent pests
(2)	Sink for hand washing
(3)	Spill kit for dealing with spills
(4)	Disposable gloves and hairnets
(5)	Fly paper away from processing equipment
(6)	Cracks caulked and sealed
(7)	Pipes smooth and made of washable material
(8)	Bottles labeled properly
(9)	Counter made of appropriate materials
(10)	Floor smooth and clean



The Processing Room

shatter-proof materials. This would include materials such as polycarbonate, lexan, or tempered glass.

It is important that fixtures in the production area also do not contaminate the product. This means installing fixtures such as lighting, ducts and pipes so that condensation doesn't drip onto the product at any stage of its production. On the same note, lighting and ventilation should be adequate, keeping the workplace well lit with a good airflow.

Drainage and Sewage

It is important that the water supply and drainage systems are of sufficient quality to allow ease of cleaning and sanitation. It is required that the production area contain a hand-washing sink (Figure 2.5.1) near the entrance, with water of between 100 and 120 degrees Fahrenheit. Floor drains and sewage systems should also be adequate for sanitary operation and proper cleaning of the facility and equipment. Promotion of good personal cleanliness in the employees is also important. Floor drains may also be a good idea in case oil is spilled and begins to pool. Such drains should lead to appropriate drainage areas.

Restrooms are an important feature which should be within a reasonable distance of the production area. They should contain a sink used only for hand washing, and should have running warm water for that purpose. It is important that the restroom be constantly stocked with disposable hand towels, hand soap, and toilet paper. Any restroom should contain a sign which details the proper hand washing methods, and serves as a reminder to wash hands after every contact with unsanitary materials.

Equipment and Handling

The equipment in the processing area in contact with the product, such as processing, holding, transferring, and filling equipment should be designed for their intended purpose, and should be of the proper quality and materials to prevent corrosion. Preferred materials include PVC piping, polished stainless steel, and other food grade plastics. Materials not recommended are copper, brass, and galvanized metals.

All surfaces, including pipe interiors and work surfaces in contact with the product should be smooth, to prevent buildup and promote cleaning. They should also be free of dirt, and be accessible to cleaning. Cleaning and sanitation should be done on a regular basis.

Employee Regulations

When ensuring that the processing area meets sanitation standards, it is not just the facility that must meet standards. Anyone coming into contact with the product or the raw materials needs to maintain a level of cleanliness protocol.

Personnel involved in the manufacturing of the product, or supervising its production, need to be properly trained to perform their tasks safely and with food safety practices in mind. Personnel involved in contact with the raw or finished product must follow certain regulations regarding clothing. These are:

Figure 2.5.1: An example of a hand washing sink with proper signs reminding workers to wash hands after contact with any contaminants.

- Personnel must remove jewelry before coming into contact with the product, as jewelry can fall into and contaminate it
- Clothing must be appropriate to

Figure 2.5.2: This is an example of a dispenser for hair and beard nets, which allows ease of access and promotes cleanliness in the workplace.

maintain cleanliness and prevent contamination

- Hair nets (Figure 2.5.2) must be worn on long hair and facial hair, to prevent it from falling into the product
- Torso hair must be appropriately covered– shirts must be buttoned or closed all the way

Lab coats are a preferable and sanitary outer wear to consider when working with the product, as they provide coverage and prevent contamination.

Not only must personnel wear the appropriate clothing, but they must also maintain a level of personal hygiene expected in a food processing environment. Personnel must properly wash hands before each shift, after using the restroom, and any time they come into contact with contaminants.

Food, drink, and tobacco products must be prohibited from the processing area. No smoking is to be allowed in the processing area, and eating and drinking is to be done in appropriate areas away from the product and raw materials.

Raw Material Handling

The materials used in processing and packaging of the product, such as the oilseed and the bottles the product will be stored in, must be stored properly prior to and after use. They must be stored above the ground, away from pests, excess moisture, and contaminants. Contaminants include microorganisms and chemicals, as well as dirt and other unwanted substances.

Raw materials must also be properly labeled and separated, to prevent mix-ups. Bags and containers must be closed when not in use, and kept away from exposure to heat, cold, light and moisture which might damage or decompose them.

Chemical Containment and Regulations

The facility used in processing of oilseeds into food products may require a number of chemicals to aid in production and sanitation. These include such materials as:

- Cleaning compounds
- Lubricants
- Pesticides
- Fuels
- Sanitizing compounds
- Other chemicals as needed

These materials are considered toxic when working with food, and should be stored separately from the processing area. Their storage area should be secure, and be labeled properly. Chemicals inside this area should be properly labeled and stored safely, in their appropriate containers. Any cleaning agents must be used as their labels describe; only sanitizers approved by the EPA are allowed for use in the processing area, and must be used according to their labels.

Regulation Administration

Regulations for food safety and processing are found under Title 21 of the Federal Code. A link to the code is

found in the references section of this section. These regulations are in turn administered and supplemented by state legislation, usually under the state department of agriculture, or department of health.

To apply for a license to process oil for general consumption in Pennsylvania, use the link to the Pennsylvania Department of Agriculture (PDA) found in the references section.

Summary

The safety of food production is important, not just for meeting regulations, but for producing a quality product which sells well and brings customers back. When considering the facility in which the oil will be produced, many things matter, such as equipment, space, sanitation, and worker cleanliness. This section reviews these important factors, so that the potential small-time food oil producer can set up a clean, safe, and functional workspace.

Resources

Penn State food science food entrepreneur site:

http://extension.psu.edu/food/entrepreneurs/starting-a-business

Penn State University Creamery Good Manufacturing Practices (to use as a reference):

http://creamery.psu.edu/plant/dairy-plant-food-safety-plans/Creamery-GMPs.pdf/view

PA Department of Agriculture licensing page (for applying to get a license):

Search Engine: “PA Wholesale Food Processing, Manufacturing and Distribution” (Look for agriculture.state.pa.us link)

US Drug and Food Administration Code of Federal Regulations Title 21:

http://www.accessdata.fda.gov/scripts/cdrh/cfdocs/cfcfr/CFRSearch.cfm?CFRPart=110

Vermont Department of Health Regulations for Food Service Establishments:

http://healthvermont.gov/regs/03food_estab.pdf

Note: This is not a comprehensive list of resources on food processing regulations. For more information, contact your regional sanitarian. In Pennsylvania, this person is found through the state Department of Agriculture.

2.6 Small-Scale Oilseed Presses:

An Evaluation of Six Commercially-Available Designs

Chris Callahan[1] and Hannah Harwood[1]
Heather Darby,[1] Doug Schaufler,[2] Ryan Elias[2]

[1] University of Vermont Extension, Burlington, Vermont
[2] Pennsylvania State University, State College, Pennsylvania

As part of a project on adding value to farm operations with food-grade oils, the University of Vermont Extension and Pennsylvania State Extension teamed up to evaluate the design and operation of several small-scale oilseed presses. While there is a great deal of interest in the production of oilseeds, many questions arise about post-harvesting processing, and many of these concerns revolve around the efficiency, affordability, and best practices of an oilseed press, which is the heart of the oilseed production system.

Most commercially-available oilseed presses have the same basic components (Figure 1). In "cold-pressing," the seed goes into a central hopper of the press and is moved through one or more screws, crushed against a nozzle and screens to extract oil without heating the seed above a temperature of 120°F. Oil and meal are separated.

Presses vary in the number and breadth of adjustment each needs and is capable of. Some presses have multiple nozzles, with differing diameter holes for differing crops (Figure 2). Some have collars that are heated to a given temperature before operation.

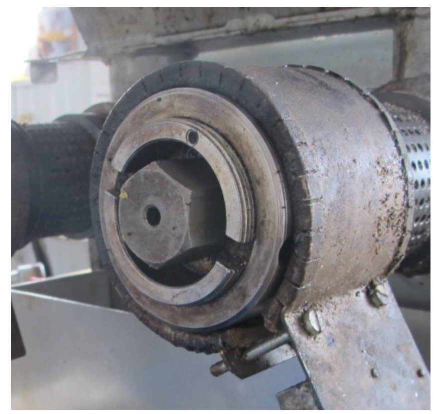


Figure 2. Nozzles vary on different oilseed press designs.

Unfortunately, manufacturers' instructions and customer service can vary greatly. Many of the presses are made overseas, and it can be difficult to get guidance in installing, wiring, and operating a press, either due to language barriers or geographical distance. In addition, the operational guidelines for different crops can vary. Here in the Northeast, where many growers are producing more than one type of oilseed crop, there is an interest in the type of press that can handle different crops, and in establishing some guidelines for commonly-used oilseed crops.

This report aims to guide both established oilseed processors in best management practices and collaborative experiences and also aid new or prospective processors in decision-making processes.

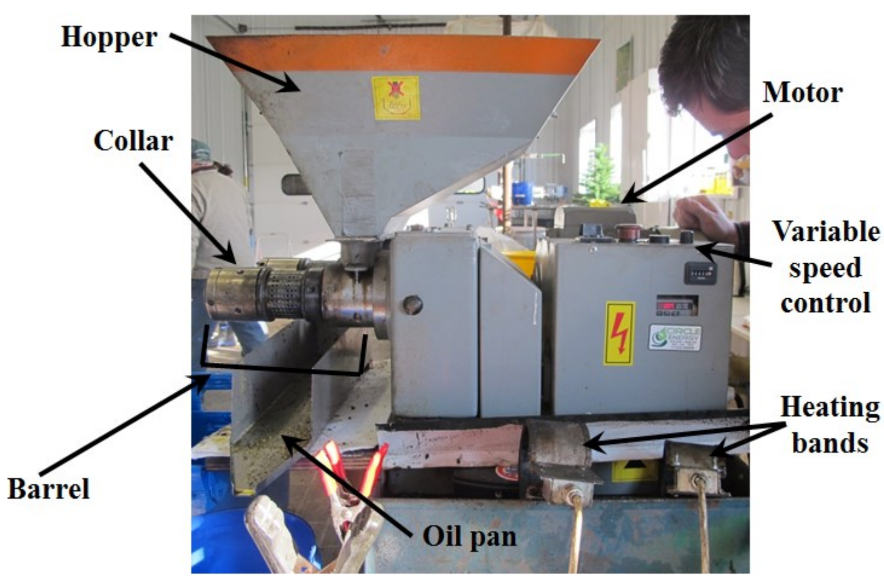


Figure 1. Standard components of a small-scale oilseed press.

Methods

Researchers visited oilseed processing facilities across the Northeast to interview press operators and conduct objective evaluations of six different press designs (Figure 3). The team evaluated the AgOil M70, Keller KEK P0020, KernKraft 40, Komet CA59G3, Oil Prince, and Täby 70 presses (Table 1).

Figure 3. Researchers and farmers work together on press evaluations.

At each press location, the same seed was used to conduct a controlled experiment. Sunflower seed (var: 'Syngenta 3480') was harvested in 2012 in Alburgh, VT; canola seed (var: '5535 CL') was harvested in 2012 in Brandon, VT; and soybeans (var: 'Boyd') were harvested in 2012 in Charlotte, VT.

Each press evaluation began with normal operation, using the individual operator's preferred tuning of the machine. The second method of operation for each press used the same basic setup but was at a faster speed (adjusted Hz/RPM) to demonstrate a higher pressing capacity. Finally, each machine was run at a lower speed (adjusted Hz/RPM) with the intent of yielding more oil. Quantitative and anecdotal data from each method (and sometimes trials at additional speeds) were noted. Each method was repeated for each of the three oilseed crops when possible.

RULES OF THUMB

- Start with clean seed.
- Test and take note of moisture (this will vary by crop and press).
- Take note of seed temperature.
- Make small adjustments as you go, rather than big changes.

Table 1. Specifications for six presses evaluated during the course of this study.

PRESS	⇓ Estimated capacity (lbs seed/24 hrs)	⇓ Approximate purchase cost + year	⇓ Power source	⇓ Rated load	⇓ Adjustable speed	⇓ Heated barrel / head	⇓ Multiple screws available	⇓ Adjustable nozzle diameter	⇓ Adjustable gap between head and screw	⇓ Ease of set-up
AgOil M70	700	$8,500 (2012)	240v	1.5 kW / 2.0 HP	X	X		X		Simple
Keller KEK P0020	1056	$8,300 (2010)	230v	2.2 kW / 3.0 HP	X				X	Simple
KernKraft 40	1200	$15,000 (2010)	220v	3.0 kW / 4.0 HP	X	X	X	X	X	Finicky
Komet CA59G3	260	$8,000 (2008)	115v AC	1.1 kW / 1.5 HP	X	X		X		Simple
Oil Prince (KernKraft 20F)	1800	$6,000 (2012)	220v	2.2 kW / 3.0 HP	X	X	X	X	X	Finicky
Täby 70	1500	$7,000 (2005)	220-240v	2.2 kW / 3.0 HP	X	X		X	X	Moderate

Press 1. AgOil M70

Roger Rainville of Borderview Research Farm in Alburgh, VT purchased an AgOil in late 2012. The cold screw press is made in the United States, one of many deciding factors for Rainville, who was interested in readily-available parts and service.

The AgOil has a simple design, with a single screw and an in-line Variable Frequency Drive (VFD) mounted on the gear box (Figure 4). With relatively few adjustments to be made, the press is simple to get running according to Rainville, and can be used to easily switch between crops without stopping to adjust.

The press itself takes up very little space, with dimensions of approximately 10”x10”x39”. A clear feed hopper allows processors to watch seed flow into the press, observing cleanliness and any potential malfunctions. A “blast gate” stops seed flow when necessary. As used at Borderview, after the band heater has brought the temperature to approximately 120°F, the heater is removed and the machine’s motor is turned on. A central screw inside the barrel forces seed against the crush plate and retainer. Meal is extruded in the form of crude pellets, and oil drips from the crush barrel’s holes.

A variable speed controller allows operators to adjust the speed of the machine and allow for the extraction of more oil. There are three different nozzles that come standard with the press; they can be swapped out for others to achieve the maximum efficiency for a given crop or condition (Figure 5).

Figure 4. AgOil 70 press at 40 RPM, pressing soybeans.

MANUFACTURER CONTACT INFORMATION

[made in U.S.A.]

www.agoilpress.com

AgOil
Mondovi, WI

(877) 645-7737
sales@agoilpress.com

Figure 5. The AgOil M70 comes with three different sized nozzles: 220, 250, and 280.

AgOil indicates that oil extraction efficiency on the M70 is 82-90% of the oil content in the seed. Trial results from this study show an average of 24.2% net oil extraction across three crops (canola yielded 24.6% oil, soybean averaged 5.7% oil, and sunflower averaged 38.6% oil).

Rainville has been satisfied with the AgOil so far, though it has a lower capacity than his other presses. Press capacity averaged 697 lbs in 24 hours over multiple crops and speed settings.

The press came with very minimal setup instructions, so initial installation was cumbersome according to Rainville. However, customer service since then has been mostly reliable with this American-made oil press. The company also provides “crush tests,” in which a sample of the grower’s particular crop can be shipped to the facility for testing.

Press 2. Keller KEK P0020

Figure 6. The Keller press has a single barrel and drive.

The German-designed Keller KEK P0020, which is approximately 51”x12”x27”, is simple, with very few adjustments (Figure 6). Only the screw speed and the distance or gap between the head and the collar leave room for fine-tuning, making the press streamlined and effective.

Operator Lloyd Byers in Liverpool, PA, purchased the press for $8300 in 2010, with freight included and an installation cost of about $600. Byers reports that the Keller is easy to set up for pressing, and requires very little supervision once running. When the press is running for long periods of time, he checks a few times a day to make sure seed flow and press operation are optimal, but can generally leave it unattended with a large quantity of seed to press.

Unlike many other small-scale presses, the Keller requires no “pre-heating” with band heaters to start. Operators simply turn on the motor, load the hopper with seed, and begin. Byers generally operates the press at approximately 32 RPMs, and uses the number of visible threads between the screw end and the nozzle as a reference for setting the gap. Oil is extracted through the crush barrel, and the meal produced is in a “flake” form (Figure 7). Byers looks for flakes about the size and shape of potato chips to indicate that the press is operating as it should. The consistency and speed of the meal is the most reliable indicator of problems with press operation. Manufacturers promise that the use of “hard-wearing” steel reduces costly maintenance and repair issues.

In this trial, the average mass oil fraction for sunflowers was 40.7%, and capacity averaged 130 lbs in 24 hours. Byers has used the Keller mainly for sunflower seed, and on the day of the press evaluation, neither soybeans nor canola could be pressed through the mill. Byers has pressed canola with great success in the past, but difficulties with soybeans remain a problem. Customer service, however, has been prompt and thorough.

Figure 7. This was the only press evaluated in this study that produces meal in the form of flakes, rather than pellets.

DISTRIBUTOR CONTACT INFORMATION

[made in Germany]

www.keller-kek.de

Distributor in the U.S.:

Elwyn Beck
Sioux Falls, South Dakota

(605) 354-1323

Press 3. KernKraft 40

The KernKraft 40 (KK40), owned and operated by Roger Rainville at Borderview Research Farm in Alburgh, VT, is a workhorse design with high capacity and little supervision required (Figure 8). Rainville's model was purchased in 2010 and has been used to press over 60 tons of seed since then.

A large hopper built into the press allows for smooth flow of seed into the two screw chambers. There is a slide closure between the hopper and screw to stop seed flow if necessary.

DISTRIBUTOR CONTACT INFORMATION

[made in Germany]

Distributor in the U.S.:

Circle Energy

Dodgeville, Wisconsin

Eric Hamilton, (608) 574-7449

info@circle-energy.com

Many adjustments are possible with the KK40: operators can modify screw speed, nozzle/die size, the distance between the screw end and the nozzle, and the heat of the barrel (with removable band heaters). There are also two available screw types (hard/deep groove or soft/shallow groove). The soft seed screw comes with the purchase of the press; the hard seed screw (useful for soybean, flax, and other crops) must be purchased separately. A small "key" is removed from one screw and placed in the other before operation. When the screw becomes scuffed, polishing it will help draw more seed through the barrel and increase overall flow (Figure 9).

Figure 8. KernKraft 40 at Borderview Research Farm in Alburgh, VT.

The KK40 has twin barrels, which increases the capacity of the press overall. In 2013 trials, average capacity for varying crops and settings was 1033 lbs in 24 hours. Average oil mass fraction was 24.8% overall (23.8% for canola, 8.2% for soybeans, and 38.0% for sunflowers).

In research trials and based small batches, the dual barrels and multiple possible adjustments sometimes led to frustration. Often, one barrel would become clogged and backed up while the other would continue extracting oil and meal effectively.

Eric Hamilton at Circle Energy has been integral in the setup, maintenance, and operation of Rainville's KK40. Hamilton has been easily accessible by phone or email and has helped troubleshoot and work through problems with the press, even traveling to Vermont to help set it up initially.

Figure 9. Scuffed screws (left) need to be polished (right) to increase press efficacy.

Press 4. Komet CA59G3

Figure 10. The Komet CA59G3 is small but reliable.

The Komet CA59G3 is made by IBG Monforts in Germany. It is an electrically-driven model that is small in size (approximately 26”x22”x23”) and capacity (Figure 10). The Komet is a typical screw-type press, with a screw bringing seed through the shaft to press oil out of it.

The Komet is pre-heated to approximately 130°F with a removable band heater prior to pressing (for approximately 10 minutes). Operators can adjust the screw speed; agricultural engineer Doug Schaufler at Penn State University generally begins pressing at approximately 55-60 RPMs.

While there is no adjustment in the gap between the tip of the nozzle and the screw, there are multiple nozzles, with varying diameters for specific crops, though Schaufler uses the 5 mm nozzle for both sunflower and canola. Because the press is a European model, all units are metric, including bolts and threads. Operators can adjust the speed of the drive.

During pressing, Schaufler looks for a reasonable output when pressing to be sure the mill is operating well. This has been determined through experience with the press on different crops. Another indicator of smooth operation is the temperature of the oil being extracted; when it gets too hot, it may be because a blockage inside the crush barrel is creating friction. Once the press is running well, there is little fine-tuning or supervision required. After the seed has been run through completely, the nozzle is removed from the press and cleaned thoroughly.

DISTRIBUTOR
CONTACT INFORMATION

[made in Germany]
www.oekotec.ibg-monforts.de/

Distributor in the U.S.:

Nebraska Screw Press
Lyons, Nebraska

(402) 307-0280

rbyrnes@nebraskascrewpress.com

Though Penn State University never received installation and operation manuals from the manufacturer, email response from customer service has been prompt and thorough. The Komet press is used at Penn State University for small batches of seed, processing approximately 500 lbs of seed per year. “This has been a real reliable, real consistent machine,” asserts Schaufler. The press has actually been used to demonstrate oilseed processing at farm shows and outreach events, being sent to various locations with little more than a one-page instruction manual on its operation.

The advertised capacity of the mill is 3-5 kg of seed per hour, which would equal up to 260 lbs of seed in 24 hours. Though the Komet was unable to be used for soybeans during these trials, the average oil mass fraction for canola was 34.4%, and sunflower seed averaged 45.1% oil. The average capacity for these two crops, across speed setting, was 193 lbs in 24 hours.

Press 5. Oil Prince (KernKraft 20F)

The Oil Prince, as it is sometimes called, is another name for the KernKraft 20F (Figure 11). This is a smaller, single-screw KernKraft model with similar adjustability and operation to the KK40 (page 5).

The Oil Prince has adjustable screw speed, nozzle diameter, and two available screw types (for hard seed and soft seed). A sliding gate between the hopper and the screw allows operators to control seed flow at the throat of the press. Operators John Hutton and Meghan Boucher at Coppal House Farm in Lee, NH heat the collar with removable band heaters and then add seed. For them, 2-3 rows of holes in the crush barrel full of dripping oil indicates effective operation.

Figure 11. Oil Prince at Coppal House Farm in Lee, NH.

When the press slows down, Boucher adjusts the sliding gate to minimize seed flow until the machine works well again. Operators find that the press clogs less frequently when run at a lower speed. Clean seed going into the hopper makes for more trouble-free pressing, and the built-in magnet on the seed hopper prevents metal from entering the mill.

Average capacity of the press was calculated at 928 lbs per 24 hours. Sunflower averaged 38.3% oil mass fraction during the trial, and canola averaged 26.6% across speed settings. On the day of the press trial, operators could not press soybeans effectively, despite an all-day attempt at data collection. The problem could have been in the moisture level of the soybeans; the Oil Prince at Coppal House Farm has not yet been used to successfully press soy (Figure 12).

Eric Hamilton at Circle Energy in WI, when called to troubleshoot this soybean problem, suggested adjustments and modifications, but said that press operation can sometimes be a moving target.

This press, relatively new to its operators, has a learning curve. During the process of troubleshooting, the team also discovered a fracture in the collar which may have been linked to a prior issue with a ball bearing being passed through the machine; this damage may have been preventing effective pressing of soybeans. While it runs extremely well and is reliable with canola and sunflower, other crops may take some adjustment.

Figure 12. Close-up of collar head and nozzle with too-hot soy meal.

DISTRIBUTOR CONTACT INFORMATION

[made in Germany]

Distributor in the U.S.:

Circle Energy

Dodgeville, Wisconsin

Eric Hamilton, (608) 574-7449

info@circle-energy.com

Press 6. Täby 70

John Williamson runs State Line Biofuels in North Bennington, VT and relies mainly on a Täby model 70 oil press as the center of his operation (Figure 13). John has pressed numerous crops (including sunflower, soybeans, canola, camelina, flax, cranbe, safflower, mustard, and pennycress) with the Täby, which requires minimal adjustments and has proven reliable over the last eight years.

The Täby 70 was designed specifically for small-scale use, and to extract oil from a wide range of crops. A 2.2 kW motor drives the press, forcing seed through the crush barrel (or "press tube") and nozzle. The press has a thermostat and speed control built into it (Figure 14), so that the drive shaft rotates at variable speeds (maximum speed is 80 Hz or 149 RPM). Operating instructions stress the importance of tightening the press collar all the way against the plate, then backing off to leave a gap of approximately 2 mm between the head and the screw.

Figure 14. Side-mounted control panel.

In 2013 trials, the average mass oil fraction was 25.3% (25.8% for canola, 7.5% for soy, and 38.3% for sunflower). The average capacity was 934 lbs per 24 hours.

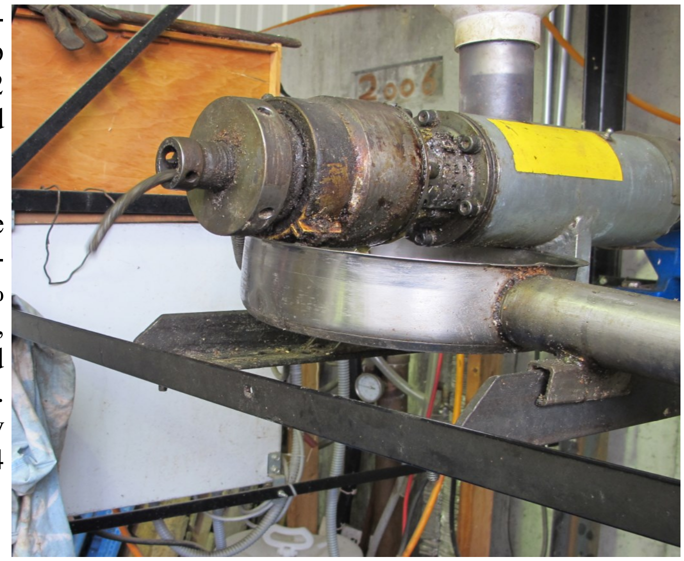


Figure 13. Täby 70 oil press with custom-made oil pan.

As with other presses, only clean seed at the proper moisture should be pressed, in order to extrude the maximum amount of oil possible. The Täby's seed hopper has a built-in magnet to prevent any metal from flowing into the press. A heater control on the gear housing stops the press from running if the collar temperatures exceed 302°F.

Maintenance requirements are minimal with this machine. Approximately every 10,000 operating hours, the gear oil should be changed. The spiral seed screw can become worn over time, and Täby suggests shipping the screw in for repair (re-hardening), rather than purchasing a new one. Using only clean seed reduces and slows the wearing-out of multiple parts.

One stumbling block with the Täby 70 is the language barrier. Manufactured in Sweden, Täby presses come with an instruction manual (installation instructions, safety warnings, and technical advice on troubleshooting and maintenance) in broken English and customer service can be delayed with minimal domestic support.

DISTRIBUTOR CONTACT INFORMATION

[made in Sweden]

www.oilpress.com

Distributor in the U.S.:

Magic Mill
Upper Saddle River, NJ

(201) 785-8840

contact@magicmillusa.com

General Findings

During the course of these evaluations we assessed individual presses and observed general trends in regards to pressing capacity and net oil yield relative to speed, as well as quality characteristics of oil.

Press Setup

It should be noted that these results represent data from a single nozzle and screw setup of each press for each specific crop (Table 2).

Table 2. Nozzle and screw type setup by press, 2013 evaluations.

PRESS	CROP		
	Canola	Soy	Sunflower
AgOil M70	7	7	7
Keller KEK P0020	N/A	N/A	N/A
KernKraft 40	6.5 Shallow, soft shell screw	9 Deep, hard shell screw	8 Deep, hard shell screw
Komet CA59G3	5	*Failed test*	5
Oil Prince / KernKraft 20	10	*Failed test*	10
Täby 70	5	5	8

N/A – The Keller press has only one option for press nozzle setup.
Failed test – The evaluation team was unable to successfully press soybeans on these presses during this evaluation.

Press Capacity

A common consideration among oilseed press purchasers is the capacity of the press, or how many tons it can press in a day. In our evaluations we explored operation of the presses at different speeds (measured as actual screw RPM) and measured the amount of seed pressed in a given amount of time. These data are summarized with capacity listed as pounds of seed in a 24-hour period (Table 3). Not all crops were run at all screw speeds. Those selected were based on operator insight and whether or not seed could actually be pressed at the given speed.

As expected, the faster the press is run, the more seed that is run through it. The press is, after all, a pump with the movement of material through it dictated by the speed of the screw that pushes the material through. However, the measured capacities vary notably by oilseed crop.

Table 3. Capacity (lbs per 24 hr) based on press and crop, 2013 study data.

Press and Screw Speed (RPM)	Crop		
	Canola	Soy	Sunflower
AgOil M70			
18.75			184
25.00	335		
31.25	427		311
37.50	533		
50.00	716	609	545
62.50		932	
75.00	568	1245	773
100.00	1284	1520	1018
Keller			
16.00			35
32.00			86
46.00			270
KernKraft 40			
18.00			382
25.00	967	665	527
40.00	1041	1081	835
60.00	2365	1588	1201
Komet			
30.00			86
37.50	118		
67.50			161
72.50	348		
76.25	217		
95.00			228
Oil Prince			
31.25			899
37.50			891
56.25	718		500
112.50	997		1140
125.00	1136		1166
Täby			
40.00			565
50.00	636	482	717
80.00	920	817	1103
120.00	1513	1361	1415

Oil Mass Fraction or Yield

A less intuitive finding of these evaluations was the relationship between oil mass fraction and press speed. Oil mass fraction is the measured proportion of oil in the test sample compared to the meal once the seed is pressed. It is often simplified or used as an indicator of oil yield.

Table 4. Oil mass fraction (%) based on press and crop, 2013 study data.

Press and 24-hr Capacity	Crop		
	Canola	Soy	Sunflower
AgOil M70			
184			**40.7**
193	22.5		
311			40.4
335	**28.6**		
427	27.3		
533	25.3		
545			39.0
609		2.5	
716	24.9		
773			37.1
932		**7.9**	
943	22.4		
1018			35.6
1245		6.7	
1284	21.3		
1520		5.6	
Keller			
35			**47.7**
86			43.9
270			30.4
KernKraft 40			
382			41.1
527			**44.3**
665		**10.1**	
835			36.5
967	**27.1**		
1041	25.1		
1081		8.0	
1201			30.0
1588		6.3	
2365	19.2		
Komet			
86			**46.9**
118	**37.2**		
161			45.5
217	34.9		
228			42.8
348	30.9		
Oil Prince			
500			41.0
718	**30.9**		
891			**42.4**
899			42.0
985	25.3		
997	26.3		
1140			33.1
1166			32.9
1287	23.9		
Täby			
482		**8.7**	
565			38.0
636	26.0		
717			**39.0**
817		7.5	
920	**27.1**		
1103			38.7
1361		6.3	
1415			37.4
1513	24.3		

Press evaluations revealed a maximum of oil mass fraction in most cases when the press was run more slowly than the default speed (Table 4; see boldface figures). The conclusion is that if an operator is interested in extracting as much oil as possible from a given seed, a slower press speed may be preferable. This is especially true if the press is underutilized on an annual basis (i.e. oversized for the current operation.)

Figure 15. Oil samples shipped to Penn State University for quality testing.

Phosphorus Levels in Oil

Phosphorus is used as an indicator of gum content in oils. Gums accelerate oxidation and therefore reduce shelf life due to rancidity. Gums can also impede effective production of biodiesel by disrupting the transesterification process most often used to make fuel from oil. In our press evaluations we subsampled oil and tested for equivalent phosphorus level using AOCS Official Method 12-55 (Figure 15).

Interestingly, phosphorus in oil is minimized at lower speeds (Figure 16). In some cases, it can be reduced by a factor of 3.7 by simply adjusting press speed.

Fine-Tuning and Troubleshooting

A learning curve is to be expected, especially when working with different crops and conditions. With all presses, there is a certain amount of troubleshooting and fine-tuning that each operator will undoubtedly go through.

For example, when seed flow slows down, as it will invariably do at times, identifying and resolving the blockage is crucial to prevent caking and overheating. Each operator involved in this project seemed to have strategies for overcoming routine problems like this. One press manu-

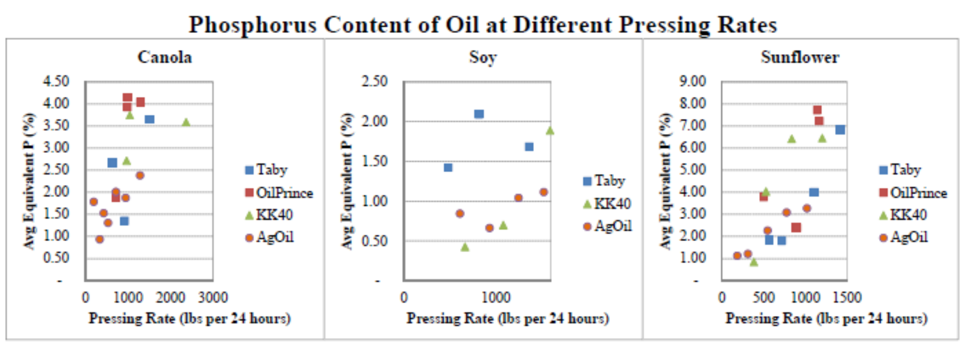


Figure 16. Effect of pressing rate on phosphorus levels in oil by crop, 2013 data.

facturer suggests mounting a thermostat and/or flow capacity controller to detect problems and automatically shut down the machine. Most agreed that the press should be stopped, cleaned out, and started again in order to identify, and hopefully fix, the problem. Occasionally, turning up the speed of the motor can help clear a blockage.

All operators mentioned the importance of taking time to learn the quirks (and strengths) of a particular press. Keeping detailed notes about the temperature, moisture, and cleanliness of seed going into the press, as well as press settings and calculated throughput, will help growers establish local operating procedures. It is our hope that this report gives prospective oilseed processors an advantage in getting started. A YouTube video complements this report and provides more information (see additional resources at right).

Table 5. General moisture recommendations and extraction rates by crop.

	Ideal Pressing Moisture (%)	Average Extraction Rate (%)
Canola	6-9	25-30
Soybeans	8-12	8-12
Sunflower	8-12	35-40

Additional resources:

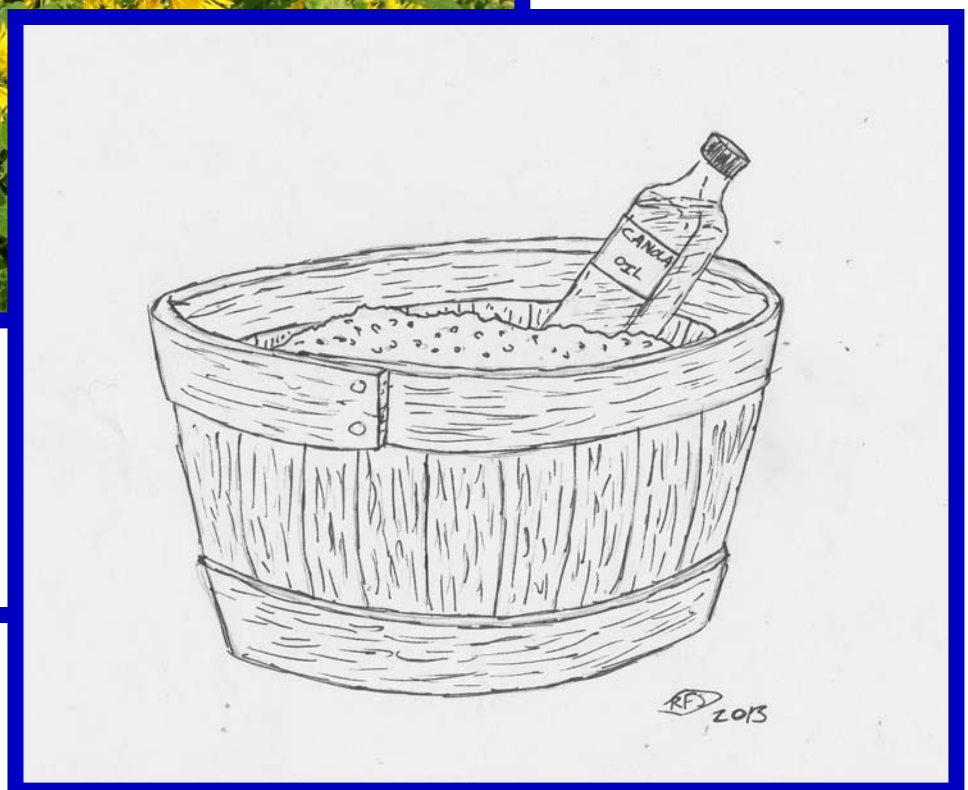
Schaufler, D. 2013. Oilseed Fact Sheet: Oilseed Presses. Penn State Univ., State College, PA. Available at http://www.uvm.edu/extension/cropsoil/wp-content/uploads/Oilseed-Presses.pdf

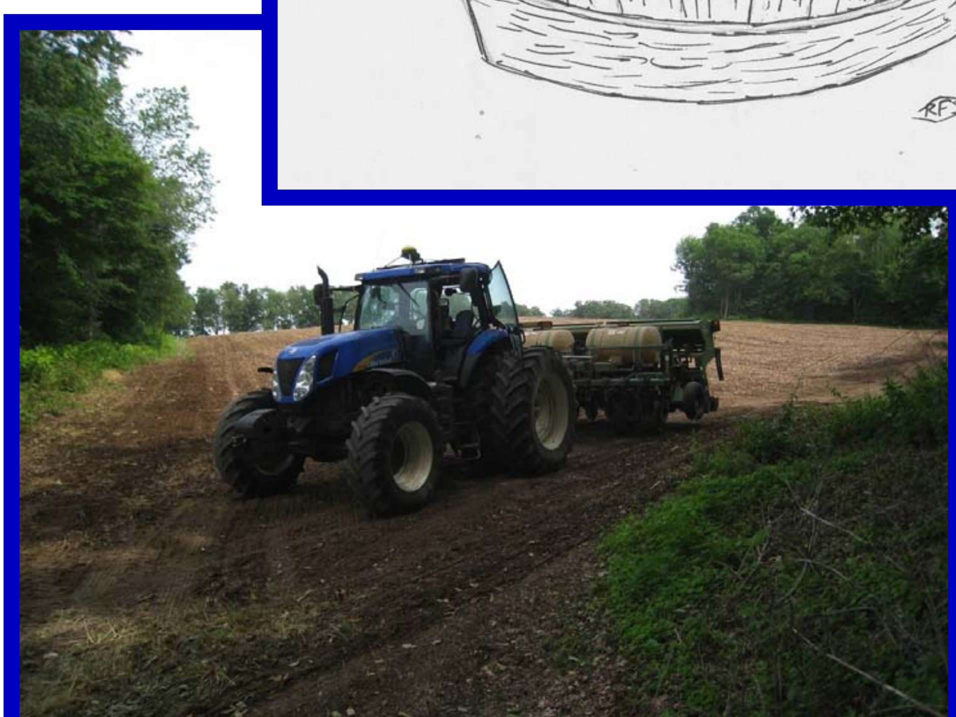
Callahan, C., H. Harwood, L. Madden. 2014. Small-Scale Oilseed Presses. University of Vermont Extension, Pennsylvania State Extension. YouTube. http://youtu.be/4bfkb_FOn3w (accessed 27 Feb. 2014).

For more information on oilseed production and processing, please visit **http://www.uvm.edu/extension/cropsoil/oilseeds**

Acknowledgements

This research project was funded by Northeast SARE Grant 11-309 “Adding Value to Oilseed Crops by Producing Food Quality Oils.” UVM Extension and Penn State Extension would like to thank the following farmers for the willing participation in this project: Roger Rainville at Borderview Research Farm in Alburgh, VT; John Williamson at State Line Biofuels in North Bennington, VT; John Hutton and Meghan Boucher at Coppal House Farm in Lee, NH; and Lloyd Byers in Liverpool, PA. Without the time and shared experience of these press operators, this project would not have been possible.


CANOLA
OIL
RFD 2013



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