Symposium

Papers from the symposium on
Extraction Processes
presented at the 73rd AOCS Annual Meeting
held in Toronto, Canada, May 2 - 6, 1982

Pre-Pressing of Oil from Rapeseed and Sunflower

J.A. WARD, Simon-Rosedowns Ltd., Cannon Street, Hull HU2 OAD, England

ABSTRACT

The current methods of prepressing rapeseed and sunflower seed prior to solvent extraction are reviewed on a stage-by-stage basis. The energy consumption numbers are examined and the overall extractability of the presscake is discussed. Possible changes in processing methods, with advantages and drawbacks, are set out.

INTRODUCTION

In the seed-crushing business, the short-term objective, particularly in today's climate, is to get the maximum financial return per ton of seed crushed. As someone outside the processing industry, I certainly do not need to remind anyone here how many factors can influence short-term profitability, many of which are completely outside processing efficiency. Preoccupation with short-term problems should not stop processors and, just as important, plant suppliers from looking forward to seek better ways of doing the same job or meeting future market needs.

PREPRESSING RAPESEED (CANOLA)

It is patently impossible to deal with the actual pressing operation without looking at its place in the complete process. The classical method of rapeseed processing is shown in Figure 1. Whether or not the entire operation can be condensed into fewer individual stages does not alter the basic pretreatment needs of the seed before its arrival at the solvent plant. That is, to give an extractable cake with good solvent desorbtion properties consistent with commercially acceptable oil and meal qualities.

Cleaning

In Europe, no one likes to clean rapeseed properly since the variable seed size gives screen-sizing problems and, besides

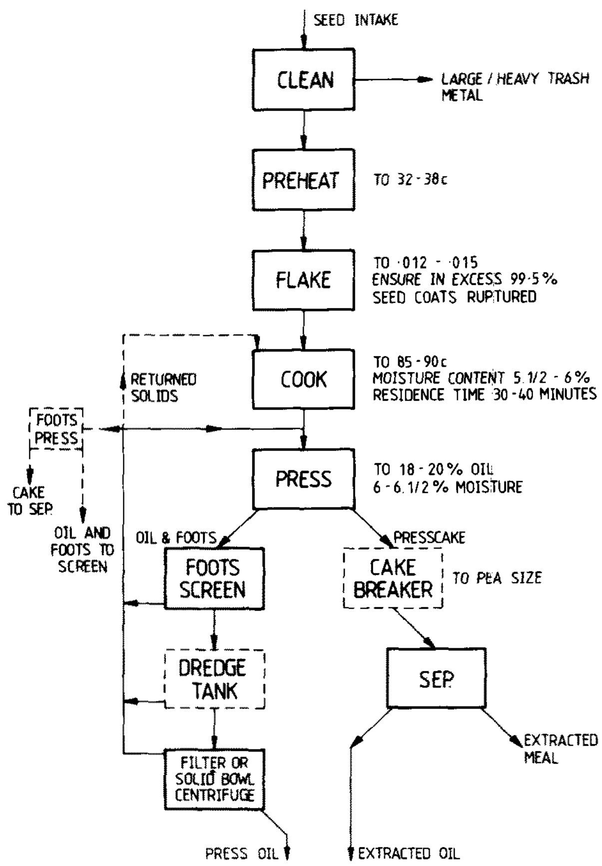

FIG. 1. Flow diagram for rapeseed (canola) processing.

having to run a dusty operation, there is an obvious disposal problem. Hence, unless there is a specific fiber, silica or protein limit to be met, the European processors perform a simple safety screening operation to remove oversize trash and metal. There is an argument which says that full cleaning should be done and fine trash blended into the extracted meal up to allowed limits to save wear and tear on process equipment. I am very doubtful whether this is worth the effort unless harvesting conditions have really bumped up the silica content.

Canadian processors can call the shots more directly on the elevator operators concerning amounts of dockage and would refer you to a fuller cleaning procedure reference (1).

Preheating and Flaking

Our investigations show clearly that the reduction of the rapeseed cell structure prior to pressing is desirable but not nearly so crucial as breaking the seed coat of virtually every seed (or, being tolerably realistic, 99.5% of all seed). The presence of whole seed in press cake is an appreciable drawback in the extractor, both in giving higher oil-in-meal numbers and increasing solvent retention.

By preheating and flaking, a fully power-effective means of rupturing the vast majority of the seed coat is achieved. Preheating cold seed is a practical necessity to prevent seed shattering and serves to reduce power on the flaking rolls and remove elasticity from the seed.

Power consumption for flaking rapeseed is quoted by various processors at between 2.4 and 3.5 KWH/ton, depending on degree of preheat. It is difficult to present a more energy-efficient and less wearing means of rupturing the seed than the two rolling surfaces of a flaking roll stand. This is particularly true when upwards of 90% of power input at the flaking rolls appears as heat, reducing subsequent steam load.

Flaked seed should be transferred directly to the cookers and should on no account be held in buffer storage in the rolled state. It is generally agreed that enzyme activity is limited until the seed is broken and is inactivated at temperatures above 70 C. It would be ideal if flaking rolls could operate delivering flaked seed at 70 C but, at this temperature, much oil is feed in the rolling process.

Cooking

The classical general list of objectives achieved by cooking for any seed can be listed as follows:

- To adjust the natural moisture content of the seed.
- To decrease the viscosity of the oil and so allow it to flow more readily from the meal. Since the pores in the meal are very much reduced during pressing, the resistance to flow must be at a minimum.
- To complete the rupturing of the oil cells started by the rolling stage. This is accomplished in part by flashing out the intrinsic moisture.
- To coagulate the protein in the seed which renders the oil separable from the meal without the expelling of proteinaceous foots.
- To sterilize the seed, destroy enzyme action and prevent growth of molds or bacteria.
- To detoxify undesirable seed constituents (such as gossypol in cottonseed).
- To fix certain phosphatides in the cake to lower the subsequent oil-refining loss.
- To produce a meal of the correct moisture content and of the right consistency for screw pressing.

On rapeseed, the coagulation of the protein and the elimination of the enzyme activity are temperature/moisture content/time-dependent. Uncoagulated protein can give problems in final clarification either by filter or centrifuge since it appears as slime on the filter leaves or as an inseparable mucous in the centrifuge. If the enzymes are not inactivated, then a small but rapid rise in FFA must be expected in the residual oil in the press cake. Also an increase in sulfur levels in the oil will take place.

Since rapeseed comes under the heading of a soft seed, the cooking of the seed, however modestly, vastly reduces the amount of foots produced in the press operation. The foots are more crisp and, where a dredge tank is used, settle out much more rapidly which reduces load in final clarification. Recycling of foots back through the system does reduce oil quality, hence foots production, although inevitable, should be kept to a minimum.

Steam consumption (at 10.5 bar) in cooking rapeseed (from 16 C), including heat input at any preheating stage, is 65-120 kg/ton, depending on the degree of drying. Power consumption in a stack cooker is 1.9-3 KWH/ton or, in a rotary tube machine, as low as 0.5 KWH/ton.

Residence time, uniformity of cooking time and control of cooking stages are all relevant to the quality of the meal going to the presses.

The cooker, whether mounted on individual presses or as a central cooking station, provides a means of coping with moisture variation and ripeness of the incoming seed.

Pressing

In this stage, the oil content is reduced from 42% to a range of 17-20%.

In common with most other equipment suppliers, my company initially used speeded-up high-pressure presses for prepress duties. These machines, although reasonably acceptable on the more fibrous seeds, were too short in the barrel and did not have the required volume for the softer seeds like rapeseed. Hence, in the early 70s, we evolved the bigger, longer-barreled slower-running G-Type press, specifically for high-capacity prepressing to match the increasing size of mill capacities.

The initial G-Type machines have undergone considerable change in worm assembly and barrel configuration during the past ten years to reduce energy consumption without sacrificing the final extractability of the cake. On rapeseed, a speeded-up high-pressure E-Type press consumed upwards of 20 KWH/ton. The original G-Type machine had a specific power consumption of 11.9 KWH/ton but, with the latest assemblies, this is now 10.2 KWH/ton.

These improvements have been achieved by careful study of the way in which the oil content of the meal in the barrel is reduced from feed to discharge end and by ironing out the high spots.

Even pressure build-up reduces power consumption, reduces foots production and reduces wear. Using the latest assemblies, the life of assembly components has improved appreciably; average life of case-hardened barrel bars is of the order of 75,000 tons of seed and of a hard-faced worm assembly, 145,000 tons.

Presscake going to the solvent plant must have extractability and percolation properties to suit the type of extractor being used. Most solvent plant suppliers would outline laboratory procedures on how the two properties could be measured. Perhaps there is a need for AOCS to publish tentative methods for plant suppliers to use a common yardstick. However, some of the factors governing extraction and percolation properties are:

- Uniformity of particle size; presence of excessive quantity of fines or excessively large pieces of cake.
- Presence of whole seed or large particles of uncrushed seed.

—The oil and moisture content of the cake.
—The porosity of the cake; this depends on the way in which the cake is formed and discharged from the press. One would always look for a small expanding effect at the press discharge, hence temperature of cake at point of discharge should always exceed 100 C.

Too dense a cake adversely affects solvent penetration and increases solvent hold-up leaving the extractor. Rapeseed cake should be broken to pea-size prior to entering the extractor but many plants find that the natural breakdown of cake in conveying equipment makes the cake-breaker redundant.

Rapeseed-extracted meal is one of the most difficult materials to desolventize, a residual figure of 1000 ppm is considered good by many operators. The need to desolventize effectively is paramount and our experience is that high residual oil-in-meal and high solvent retention go together.

Oil Clean-up

The objective here, simply, is to obtain clarified oil and to return the solids back into the system as oil free as possible.

When processing a soft seed we normally recommend using a gyratory/vibrating screen dressed with 30 mesh or rather finer so that the coarse foots are taken out immediately. This serves two purposes in that the coarse foots do not soak and soften in the dredge tank and the screened oil presents fewer pumping problems.

The use of a dredge tank after the screen also serves two purposes; firstly, it acts as a useful buffer between the presses and final clarification and, also, removes a further amount of solids, thus relieving load on the filter/centrifuge.

The solid bowl centrifuge (Super-D-Canter or similar) is a very elegant method of final oil clean-up. It does have two drawbacks in that it needs the addition of a small quantity of steam to give efficient solids separation and the centrifuge manufacturers do not normally guarantee better than 0.1% residual solids. Although the addition of water hydrates some of the gums, which is a good thing, it is not possible to guarantee a dry oil and a subsequent vacuum drying operation is needed. Hence, the centrifuge can only be described as ideal when the clarified oil is going more or less directly into a refining line. If a centrifuge is used, we would recommend strongly a standby unit and/or adequate buffer capacity ahead of the unit.

The alternative to the centrifuge is a pressure leaf filter which can achieve solids contents below 0.02% and, in its automated form, requires minimal labor. Again a pair of filters operating in tandem is recommended. On oil from normally cooked seed, a perfectly satisfactory filter medium is formed on the leaves. Filter aid to precoat the leaves is not necessary; in any case, recycling filter aid to the presses is the surest known way to wear out worm assemblies.

In a well run rapeseed prepress plant, the BD solids content of expelled oil is between 3 and 5%, i.e., between 6 and 10% foots by volume. In general terms, double zero varieties of rapeseed produce more foots than the European varieties since they are softer. Again in broad terms, 65-75% of the solids should be taken out in the foots screen and the remainder in the dredge tank and/or final clarification.

Solids Return

In large plants (ca. over 600 TPD), the use of a foots press can be considered. This machine produces a highly extractable cake because it is formed from meal which has been heavily milled and extruded through the prepress barrel.

Where a foots press is not used, it is advisable on rapeseed to recycle the solids direct to the press, not through the cooker, if the mill layout allows.

SUNFLOWER PROCESSING

We can now, much more briefly, run through sunflower processing, pointing out the differences with rapeseed. Sunflower can be processed undecorticated or decorticated. Briefly, we should look at the argument for and against decortication.

For decortication:

—Plant capacity is increased proportionally by upwards of 20% and with appreciable energy saving.
—Sunflower hulls are abrasive so that wear and tear in the plant, particularly in the presses, is much reduced when working decorticated seed.
—Overall oil yield is increased; solvent losses are reduced.
—The protein value of the extracted meal is increased, in broad terms from 28% to 41%.

Against decortication:

—The hulls are a useful boiler fuel (ca. 8,100 BTU/lb) but, unless they can be used in this way, they present a disposal problem because they are light (ca. 8 lbs/ft^3) and have little commercial value.
—Current varieties of sunflower seed have been bred for oil content and yield but do not decorticate well. It can be difficult to keep the meats content of the hulls stream down to an acceptable level. In practice, most processors with decortication plants remove only a portion of the hulls, sufficient to raise the amount of steam they require.

Undecorticated Seed

The simple processing diagram for undecorticated seed is shown in Figure 2. The high fiber content gives a higher power consumption in the presses, hence the rolling serves mainly to break up the shell. Some operators grind the seed coarsely before rolling and pressing.

Principal utility requirements for undecorticated seed are: (a) power used in rolling 5.0-6.0 KWH/ton, (b) power used in pressing 17.6 KWH/ton (unrolled seed), (c) power used in pressing 13.3 KWH/ton (rolled seed) and (d) steam requirement 67-123 kg/ton. Presses working undecorticated sunflower would normally carry hard-faced worm assembly and barrel bar components. In machines where seed is rolled before pressing, a 'life' of both sets of components is of the order of 45,000 tons. In plants where the rolling stage is omitted, the life is reduced by over 30%.

Decorticated Sunflower Seed

Flow diagram for decorticated sunflower seed processing is shown in Figure 3.

There is a normal practical minimum of 8% hulls in the meats sttream which, besides easing decortication plant settings, gives a little 'bite' to the meal in the pressing operation. The flaking of the meats before cooking is an important stage.

The meal is cooked to a rather higher temperature so that production of foots is reduced and foots separation improved.

Principal utility requirements for decorticated seed are: (a) power used in rolling 2.5 to 4.0 KWH/ton of meats, (b) power used in pressing 10.5 KWH/ton of meats and (c) steam requirements 75-132 Kg/ton of meats.

Presses working decorticated sunflower would normally carry hard-faced worm assembly components and case-

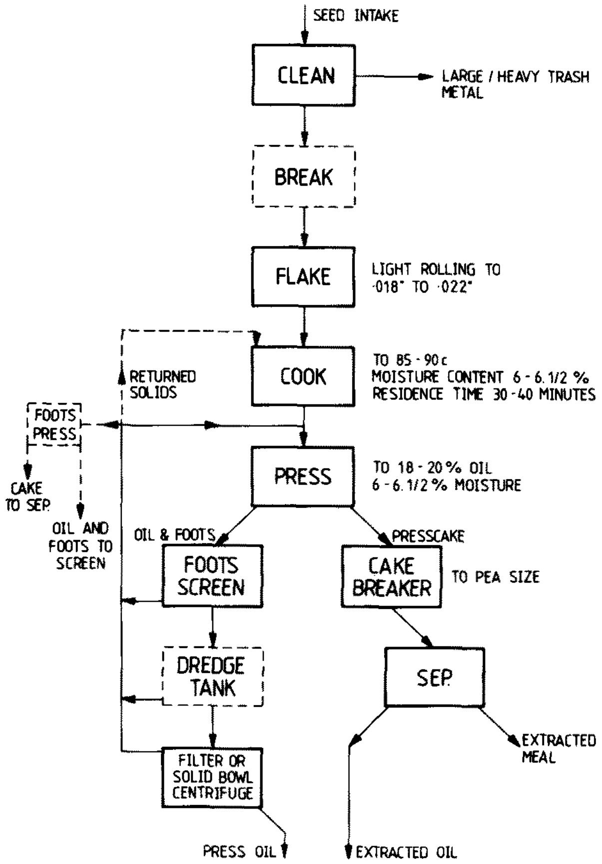

FIG. 2. Flow diagram for undecorticated sunflower processing.

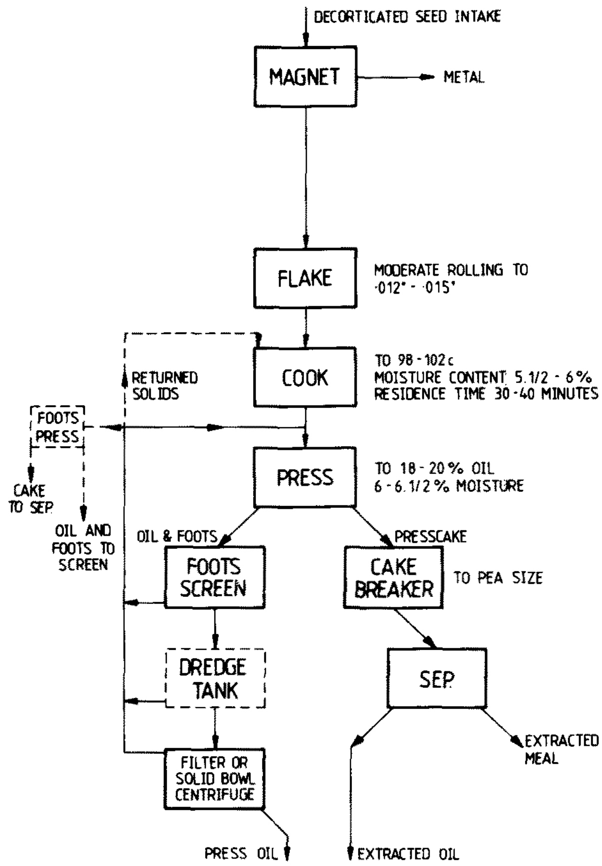

FIG. 3. Flow diagram for decorticated sunflower processing.

hardened barrel bars, giving working life very similar to rapeseed and 20% better in some cases for the worm assembly components.

DIRECT PRESSING OF SUNFLOWER AND RAPESEED

For some years, my company has marketed very small direct pressing machines for use in village or on-farm applications. These tiny machines take cold, whole seed and, although a little temperamental, can produce undecorticated sunflower and rapeseed cakes at between 13 and 18% oil in cake. We market at two sizes, 40 and 200 kg/hr, driven by 2.2 and 11 KW motors, respectively.

We noted some time ago that cake from these machines, particularly the smaller unit, was acceptably extractable and did not suffer the drawback of whole or uncrushed seed since the final cake orifice can be very small on these tiny machines.

This led us to operate a conventional high-pressure press (our Mark 5 machine) on direct pressing of cold whole seed. Mark 5 machine was chosen in preference to the standard G-Type prepress because of its greater strength and input power/shaft revolution.

On undecorticated sunflower seed, a perfectly extractable cake can be produced with the following performance data: capacity 109 tons/24 hr; oil content 21.5%; power consumption 147 KW (= 24 KWH/ton).

The cake was only marginally less extractable than cake from ground, cooked cake from a G-press in the same line. Foots production on a BD basis was higher by 34% than from the G-press. FFA in the cold-pressed oil was marginally higher but the phosphorus content in the cold-pressed oil was better. Hence, there is no reason why whole undecorticated sunflower should not be cold pressed to give an acceptable cake in a suitably engineered press which my company is quite prepared to offer. In applying so much power, the concern on undecorticated sunflower must be in the area of press component wear. As a point of interest, many G-Type presses in service run on partially decorticated sunflower with the rolling stage completely omitted.

Initial tests on rapeseed using conventional equipment were very discouraging so we transferred our investigation to our own test house on a test rig capable of handling ca. 1½ tons/hr. We can produce a good-looking cake at ca. 21% oil, but we have not solved some persistent problems, notably the presence of whole seed in the cake, the high quantity of foots production and a degree of filtering and wear problems.

FUTURE POSSIBILITIES

The inevitable question is always whether there is some other means of preparing sunflower and rapeseed for solvent extraction without the need for a screw press or a derivative in the system. Soybean, decorticated cottonseed and palm kernels can all be extracted directly. Direct extraction of sunflower and rapeseed can be, and are being, done but not with a notable advantage over the classical methods. My company, and, I guess, all other plant suppliers and processors, continually seeks the more elegant and, hopefully, universal way to treat all oilseeds. When we have found it we will let you know!

One could always pose the above proposition in reverse and ask whether, in the case of rapeseed, if a presscake having around 6% oil content can be produced, solvent extraction is worthwhile under all circumstances.

REFERENCE

1. Hopkins, D.S., JAOCS 54:481A (1977).

[Received August 17, 1982]