Laboratory Oilseed Processing by A Small Screw Press

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Applicability of the small screw press as a laboratory tool in processing oilseeds was investigated. The meal and oil produced from peanuts in a small press were physically characterized. A simple set of standards was established for relating the oil extraction efficiency and the meal oil content to the physical and visual qualities of the meal produced. This will assist a researcher in maintaining in-process control of the quality of screw press products. These standards were used to identify the conditions of maximum peanut oil recovery. Results with screw pressing of peanuts are compared to studies of other oilseeds.

Although the commercial-size screw press used in pressing oil from oilseeds has been replaced largely by solvent methods, the small screw press has many useful applications as a laboratory tool. Such units typically have capacities less than 250 kg/hr, adequate for research-scale processing of oilseeds. Recent work has shown that the small expeller is capable of over 90% oil recovery from oilseeds (1). Although new equipment is commercially available, there is a need for well-defined operating parameters. Without such parameters, very poor results may be obtained by the inexperienced user of the press.

The screw press provides a simple, mechanical method for laboratory preparation of oilseed flours, feed development, and oilseed quality control. It provides a nonsolvent method for oil recovery. The latter may be of particular importance when studying novel oilseeds. Harris et al. (2) reported the use of a small Hander press to produce defatted flours, meals and grits from peanuts. Backer and others et al. (3,9-10) used a similar press to produce sunflower and soybean oil in the laboratory. Thompson et al. (4) produced high yields of oil from winter rape, safflower, peanuts and fennel. He evaluated the meals as livestock feed. Bagby (5) has described promising novel oilseeds which could be conveniently studied via the mechanical press.

The press is of simple and sturdy construction and easily maintained and operated in the laboratory without much supervision. It can be adapted quickly to processing different varieties of vegetable seeds. The pressing is a continuous operation with the products being made within a few minutes of the start of processing. It simplicity and safety are advantages over the more efficient solvent extraction equipment. There are several manufacturers of small presses, including Hander and Simon-Rosedowns.

This study reports the use of the small screw press in producing peanut meal and oil in the laboratory and shows how the quality of the products can be estimated from their physical characteristics. Oil recovery may be controlled as desired. A comparison of the press operation is made for several oilseeds in order to indicate the usefulness of this process as a research tool in the laboratory.

EXPERIMENTAL PROCEDURES

The Hander New Type 52 model screw press with a capacity of 30 to 50 kg of peanuts/hr was used in this study (Hander Oil Mill Machinery Company, Osaka, Japan). This unit has a screw conveyor, the expeller screw, rotating inside a barrel. Feed entry and meal discharge points are shown in Figure 1. The volumetric displacement of the screw decreases from the feed end of the barrel to the discharge end so that the seeds were subjected to high pressures squeezing the oil from them. Expressed oil drained out of the barrel through slits between the expeller bars (Fig. 1). The screw press was run by a motor rated 2.2 Kw with a screw speed of 82.25 rpm. It has 16 expeller bars of rectangular section which comprised the barrel, with a gap of 0.36 mm between adjacent bars.

The meal was discharged through a circular aperture between the tapered end of the screw and the barrel. The size of the aperture was varied by the pressure-adjusting crank which moved the screw axially. The smaller the aperture clearance, the higher the pressure, and vice versa.

The screw press was instrumented, for internal pressure measurement, with pairs of strain gages (type WK-060-125BT-350, Micro-Measurements, Raleigh, North Carolina) at the middle and discharge point of the screw housing. The gages were mounted in half-bridge Poisson arrangement for temperature compensation. The signals from the bridges were multiplexed and recorded on a single pen strip chart recorder.

Copper Constantine thermocouples were mounted inside the feed hopper and on the outer surface of a top expeller bar. These measured the temperature of seeds entering the machine and of expelled oil, respectively.

Experimental design and procedure. The oil recovery was influenced by the seed moisture content, seed

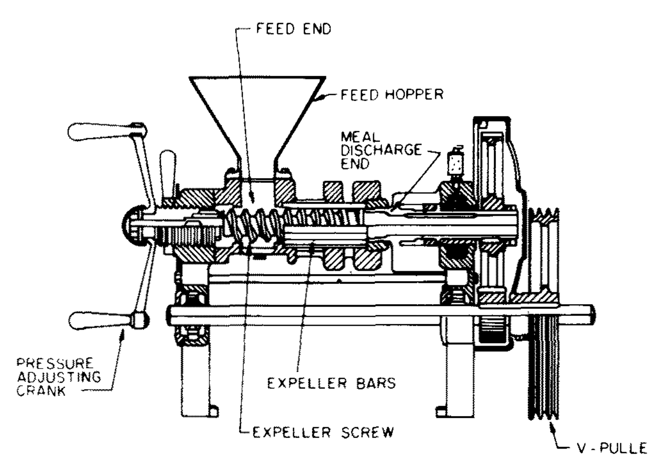

FIG. 1. Sectional drawing of Hander screw expeller.

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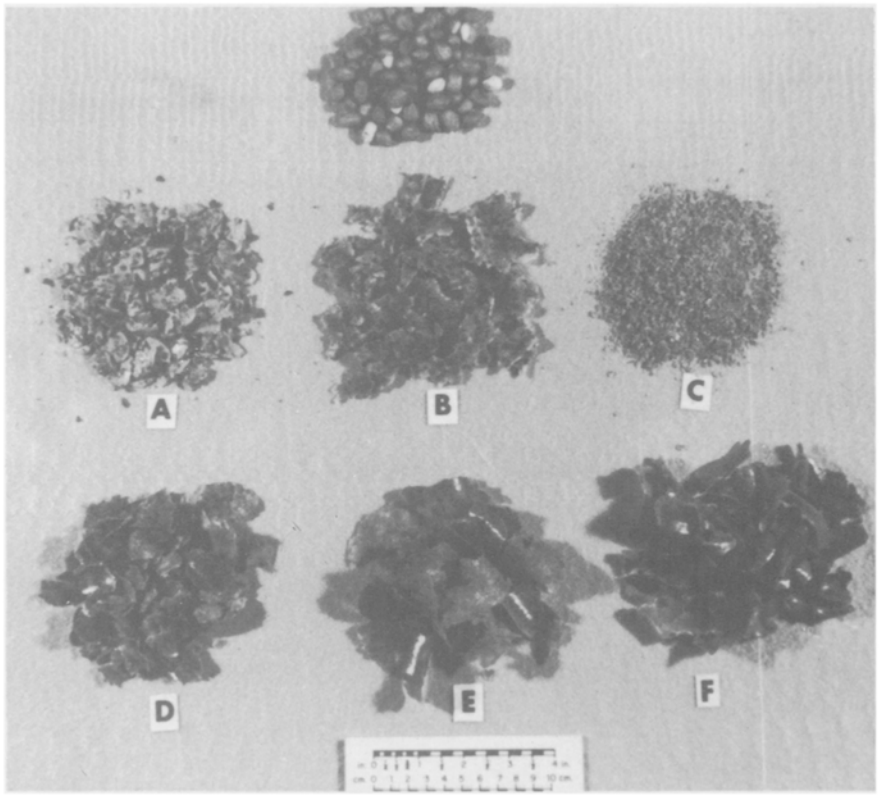

FIG. 2. Samples of peanut meal of varying physical characteristics.

temperature, period of preheating, and the pressure inside the screw press barrel (1). A set of experiments was statistically designed to determine the point of maximum oil extraction by varying the above factors (6). Forty-three different experiments were conducted with oil extraction efficiencies ranging from very low (26%) to very high (92%). The optimum efficiency was determined by response surface analysis to be 93%. The peanut meal and oil were characterized for arriving at meaningful relationships.

The oil extraction efficiency was determined by the ratio of the filtered quantity of oil/100 g of peanuts to 49.88, the average moisture-free oil content by weight.

The expeller screw and the interior of the press were preheated by electrical resistance heaters prior to conducting an experiment. Approximately 4.5-kg samples of peanuts were preheated in a rotary roaster for each test.

To conduct a test, the peanuts were fed to the screw press, and the screw pressure was increased gradually until oil began to flow. the pressure was reduced slightly after the appearance of meal expelling with the oil and/or clogging of the meal discharge port. The strain gage readings on the strip chart recorder gave an indication of the internal pressure. The oil temperature was indicated by thermocouple. Within three minutes, the oil temperature and internal pressure were observed to become fairly constant. Samples and mass balances were obtained during this quasi steady state. The oil collected was filtered to obtain clear oil. The meal was analyzed for residual oil content by a standard hexane extraction method (7).

RESULTS AND DISCUSSION

Peanut meal characteristics. At conditions giving high oil extraction efficiencies, the meal produced was crisp and brown in color and discharged from the screw press in a thin, continuous stream. This meal had a shiny polished surface on the side in contact with the screw shaft and a dull, course surface on the other side. Operating conditions corresponding to low oil extraction efficiencies resulted in meal production which was in discontinuous pieces, light yellow in color, oily and relatively thick. The meal also contained peanut skin fragments visible as light brown particles.

Figure 2 shows pictures of a representative selection of six meal samples arranged in the order of increasing oil recovery. They are described fully in Table 1.

The curvature of the response surface of the peanut oil extraction efficiency was rather slight near the point of maximum oil recovery. Correspondingly, the visible meal characteristics were nearly constant from 85 to 93% oil recovery from peanuts. Visible changes in the meal indicated to the operator that he was significantly deviating from optimal oil recovery.

In a few instances in the low and medium ranges, different peanut meal characteristics corresponded to the same recovery fraction. These variations disappeared in the high oil recovery regions. Variations in meal characteristics for the medium and low oil recovery regions may be related to the geometry of the screw press response surface. Sivakumaran (1) found that the response surface of the oil recovery fraction in this study was shaped like a "hill." The low values

TABLE 1

Physical Characteristics of Peanut Meals Produced

Specimen	Oil extraction efficiency	Meal oil content	Meal characteristics			
			Color	Thickness	Texture	Discharge
A	18.4	44.5	Light yellow	2.12 mm	Oily with visible embedded peanut skin particles	Discharged in discontinuous pieces
B	43.7	35.9	Light yellowish black with light black patches	1.92 mm	Oily with embedded peanut skin pieces	Discontinuous pieces larger than those of Specimen A
C	61.3	29.2	Light yellowish orange		Crumbled when touched	Discontinuous flakes smaller than those of Specimens A & B
D	71.6	21.6	Light, dirty brown	0.92 mm	Soft and crispy; shiny and polished on one side and dull and coarse on the other	Discontinuous flakes larger than those of previous specimens
E	81.0	14.4	Darker, dirty brown	0.94 mm	Crispy; shiny and polished on one side and dull and coarse on the other	Discontinuous pieces larger than all previous specimens
F	89.4	5.6	Brown	0.84 mm	Hard and very crispy; shiny and polished one side and dull and coarse on the other	Continuous discharge from the machine

of recovery corresponded to the base region of the hill, medium recovery to the middle region and high recovery to the top. The apex of the hill corresponded to the maximum oil recovery. Thus, in the medium and low oil extraction regions, a given recovery level can be obtained by combinations of very different levels of processing variables. These different levels of the processing variables produced, for the same recovery, different meal characteristics. However, quantitative deductions about the operating levels of the factors cannot be made by studying the physical characteristics of the meal produced, especially in the medium and lower oil extraction regions.

The meal properties listed in Table 1 can be used as a reliable guide to estimate the oil extraction efficiencies. The researcher can certainly identify the region of maximum oil extraction efficiency with reasonable accuracy because the meal properties are fairly constant in this region.

In general, as the oil extraction efficiency increased toward its maximum, the peanut meal could be characterized by its:

- Color—turned from light yellow to brown color
- Thickness—became thinner, often less than one mm
- Texture—changed from soft to a crisp and harder texture resembling commercial "corn chips"
- Discharge pattern—discharged continuously from the machine rather than in pieces.

Using the characteristics listed in Table 1, a user of the screw press will be able to make a visual and tactile inspection of the peanut meal expelled and identify the range of recovery efficiencies he is obtaining. He also will be able to change operating conditions incrementally to produce the desired level of oil recovery.

E. Worthington (1983) has communicated privately that he obtained 80 to 85% oil extraction from peanuts and a meal characteristic of a continuous, thin, brittle film in this range. This agrees with findings of the present study.

Meal characteristics of sunflowerseeds as a function of oil recovery show trends similar to those observed for peanuts (8). Meal oil content, thickness, texture and color are in good qualitative agreement with observations made for peanut meal. Under light pressure in a small screw press, the meal had the appearance of crushed sunflowerseeds; hull pieces were discernible, meal was light in color and it contained most of the oil. Meal thickness was greater than one mm, and the flakes fell apart easily. At a higher pressure, the meal was considerably dryer and darker with large flakes 0.4 to 0.6 mm thick. The oilseed mass flow rate and the oil recovery fraction were also high. When the pressure was increased further, the meal formed smaller diameter flakes, was more brittle and darker with flakes 0.25 to 0.40 mm thick. The press capacity decreased but the oil extraction efficiency remained constant.

Peanut oil characterization. The oil produced was muddy and brown in color as it flowed from the screw press containing pieces of peanut skin and fine solids. When the oil was allowed to stand for a day or two the solids settled to the bottom, leaving clear oil above. Filtered oil was clear and transparent. Oil produced

TABLE 2

Physical Characteristics of Peanut Oil

Oil extraction efficiency (%)	Oil characteristics	
	Consistency	Color
Low (below 50%)	muddy	Brown; filtered oil was light yellow, clear and transparent
High (above 80%)	muddy	Brown; filtered oil was light brown, clear and transparent

under low temperature, low efficiency conditions was light yellow in color while the high temperature, high recovery conditions produced oil of a light brown color.

As the extraction efficiency was gradually increased from low to high, changes in the physical qualities of the expelled oil were not as marked as with the peanut meal. It could only be said that at high efficiency, filtered oil was light brown in color. At low efficiency, filtered oil was light yellow with intermediate qualities being a mixture of both colors, not discernible to the eye. Table 2 charts the variation of the physical characteristics of the oil.

In most cases the fine solids content in the unfiltered oil was less than 10% by weight of the total fluid collected. The fine solids filtered out from the expelled oil had moisture-free oil contents ranging from 30.5 to 35.7% by weight.

A comparison with sunflowerseed oil expressed in a small screw press (8) shows that sunflowerseed oil had a muddy consistency as the machine was started up cold but became clearer and pale green in color when warmed to operating temperature.

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