Sunflower Processing Techniques[1]

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Abstract

A great deal of interest has recently been shown in sunflower seed as an oilseed crop. The introduction of new Russian seed varieties with higher oil content have helped to stimulate this interest, particularly in the flax and cottonseed growing areas. This paper presents background material pertinent to the subject of sunflower processing. Such things as seed structure, oil and meal quality and certain economic considerations are included. Processing techniques currently used are discussed and comparisons made with the processing of other oilseeds. Brief mention is made of storage and handling of the seeds, meal and oil. Extraction is discussed briefly, but since it is successful only if the seed is properly prepared, seed preparation and handling prior to extraction are stressed. Sunflower seeds are nearly 30% hulls and these hulls are high in crude fiber content. For this reason, dehulling and hull separation practices are important aspects of processing sunflowers. Expeller operating variables are also important where prepressing is part of the process. These processes are stressed. Direct solvent extraction and prepress solvent extraction methods are currently being used successfully. Features of both methods and their applicability are discussed along with seed preparation needed for each method.

Introduction

Sunflowers were found in America by Spaniards in the 16th century. They spread through Europe to Russia where, 100 years ago, they were first used as an oilseed crop. Table I gives recent USDA estimates of sunflower production for the world and for the major producing countries.

Several factors have spurred recent interest in the United States in sunflowers as an oilseed crop. These include the introduction of new Russian seed varieties with higher oil content, disease and pest resistance, and suitability to many growing areas (1). They can be grown successfully in the Red River Valley area and in cottonseed growing areas where many mills have surplus crushing capacity and many farmers need an additional cash crop for idle acreage or to replace crops presently showing small profits.

Problems exist for sunflower growers. These include moths, wilt, late maturity, black birds and equipment modifications, but the biggest deterrent to increased acreage at present is economics. World price is influenced by large exports for the USSR.

Properties of Oil and Meal

Extensive literature does not exist on the oil products, but sunflower oil is used as an edible oil. It is characterized by a low linolenic acid content (0.3%) and by a relatively low level of natural antioxidants (2). Waxes are present mainly in the hull fraction, which require refrigeration of the oil. Because of its low linolenic acid content and its classification as a semi-drying oil, it is used in alkyds, urethanes and other coating materials for its nonyellowing properties. Table II contains analyses of some typical sunflower oils from three different areas.

The Northern Regional Laboratory recently analyzed a sample of tank bottoms from crude sunflower oil. They were found to contain a large amount of waxes. The waxes result from a random combination of alcohols and acids which have their origin in sunflower seed hulls (Kleiman et al., unpublished data).

Table III contains analyses of sunflower meal compared with analyses of typical meals from two other oilseeds (3).

Research has shown sunflower meal to be a high quality source of protein for livestock rations (4–6). It has been readily accepted by livestock feeders. Care must be taken in the formulation of nonruminant rations to provide adequate lysine, because sunflower meal is low in this amino acid. For swine and poultry rations which are nutritionally balanced, sunflower meal should be equal in value to other oilseed meals in supplying a portion of the needed protein.

Sunflower processing variables will affect the quality of protein, denaturation and relative protein efficiency. No nutritional toxins have been reported in sunflower meal.

Storage and Handling

Seed grown in northern areas and harvested late often has a high moisture content. Moistures of 15–20% are sometimes found in seed delivered to the processor. As with other seeds, time and temperature are important, but moisture is the critical factor in storage. Twelve per cent moisture should be considered maximum for storage of seed. Moisture in excess of this amount will cause storage fungi to develop and produce an inferior quality oil. Anyone planning to store sunflower seed should be prepared to dry it before storage for any appreciable length of time.

The oil poses no special handling problems. It behaves more like linseed oil than soybean oil at low temperatures. Heated storage is advisable but not necessary for outside storage in cold weather.

Processing

Sunflower seed has been processed by soybean, linseed and cottonseed plants, by direct solvent extraction and by prepress-solvent extraction methods. There are many similarities in handling and a few differences. Table IV describes some properties of sunflower seed vs. other oilseeds (4).

[1] One of nine papers to be published from the Symposium on Solvent Extraction Techniques for Soybean and Other Seeds, presented at the AOCS Meeting, Minneapolis, October, 1969.

TABLE I

USDA Estimates of Sunflower Seed Production in 1967[a]

Production areas	Metric tons
World total	9,300,000
USSR	6,100,000
Eastern Europe	1,500,000
Argentina	1,100,000
Turkey	215,000
USA	75,000

[a] Estimates of the Foreign Agricultural Service of the U.S. Department of Agriculture.

TABLE II

Gas Liquid Chromatographic Analysis of Methyl Esters of Three Sunflower Seed Oils (Area Per Cent)[a]

Component acid	A	B	C
14:0	0.1	0.1	0.1
16:0	6.1	6.0	6.7
16:1	0.1	Trace	Trace
17:0	Trace	Trace	Trace
18:0	4.2	4.6	4.3
18:1	14.9	15.2	17.0
18:2	73.5	73.0	70.9
18:3	0.2	0.3	0.2
20:0	0.2	0.3	0.3
22:0	0.7	0.6	0.5
IV[b]	139.0	139.2	137.5
IV[c]	139.8	139.4	137.1

[a] Data from Minnesota Linseed Oil Co., 1968.
[b] Iodine value observed experimentally.
[c] Iodine value of esters calculated from GLC analysis.

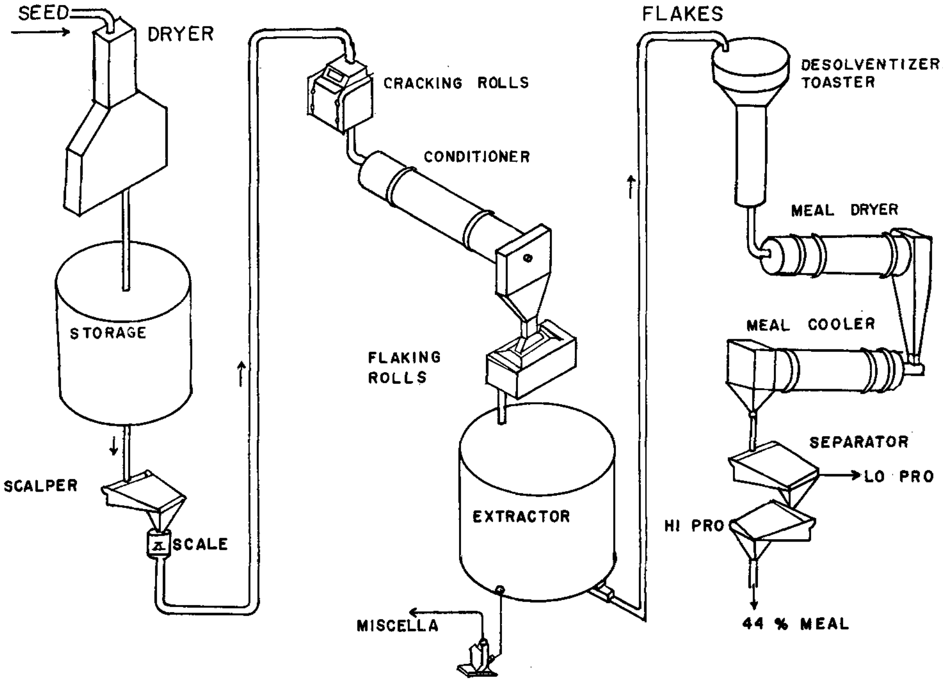

FIG. 1. Flow chart of sunflower solvent extraction plant.

The properties of sunflower seeds which cause differences in processing are the high percentage of hull content, the low bulk density, and the high crude fiber content of the hulls. There is a potential fines problem from the meats breaking up during the hulling and hull separation processes.

Seed Cleaning

Sunflower seeds are probably the cleanest seeds taken into a mill, due mainly to the fact that the combine is set so high for harvesting. Cleaning of sunflower seeds usually consists of putting them over a scalper to remove the large pieces of stems and leaves. Little or no problem is encountered with sand or small weed seeds. Equipment subject to abrasion such as rolls, usually last longer on sunflower seeds than with other oil seeds.

Direct Solvent Extraction Process

Most of the information on this process was obtained from the Sun Plant Products Co. at Gonvik, Minnesota, the only direct solvent extraction plant in North America which has operated a major portion of the year on sunflower seeds. This process for sunflowers is quite similar to that for soybeans. No head-end dehulling is used because an excess of fines is produced which would plug the extractor. Figure 1 is a flow sheet for the process.

The cracking rolls, two pair high with 5 and 10 corrugations per inch, are set for a minimum of attrition. The seeds should not appear to be dehulled, but as the seeds go through the conditioner, the meats and the hulls separate.

The cracked seeds are conditioned at 150 F and the moisture adjusted to 10–10½%. Excess moisture causes the flakes to become gummy and lower moistures produce too many fines, either of which condition causes incomplete extraction.

Flaking rolls should produce flakes of .010–.012 in. Thinner flakes produce too many fines. Mass flow conveyors should be used to move flakes to the extractor and minimize the amount of fines produced.

Extractors currently being used for other oilseeds are suitable for sunflower processing. They operate efficiently at 50% of rated capacity for soybeans. This figure can be pushed to 60% or even 65% but residual oil content of the flakes increases with increasing production rates.

Desolventizing of the flakes should be done below 200 F. Live steam can be used but it causes the meats to adhere to the hulls and this precludes later separation. If the screen separation is to be accomplished, live steam must not be used in the desolventizing process.

The desolventized flakes can be screened into three fractions. A typical analysis of these fractions is shown in Table V.

Advantages of the process include: lower capital investment, simplicity of operation, better quality meal fraction, and better quality crude oil. Plants not equipped with expellers can process sunflowers with slight equip-

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TABLE III
Average Composition of Selected Oilseed Meals[a]

Composition	Sunflower meal		Cottonseed meal		Soybean meal
	Expeller	Solvent extracted	Expeller	Solvent extracted	Solvent extracted
Moisture	7.0	7.0	7.0	9.0	11.0
Ash	6.8	7.7	6.1	6.5	5.8
Crude fiber	13.0	11.0	11.0	11.0	6.0
Ether extract	7.6	2.9	5.8	1.6	0.9
Protein	41.0	46.8	41.4	41.6	45.8

[a] Ref. 3.

TABLE IV
Comparative Data on Oilseeds, Hulls and Meats

Composition	Seed		
	Sunflower[a]	Cottonseed[b]	Soybean[c]
Whole seed			
Hull, %	24	36	8
Oil, %	39.6	19	20
Protein, %	13.6	21	42
Crude fiber, %	14.4	10	5
Moisture	10	9	7
Test weight	28 lb/bu	32 lb/bu	56 lb/bu
Hull			
Oil, %	1.8	1	
Protein, %	5.3		
Crude fiber, %	50.5	33	
Ash	2.6	1.8	
Moisture	8.5		
Kernel			
Oil, %	50.3	30	
Protein, %	24.7	30	
Crude fiber, %	2.5	4.8	
Ash	4.2	4.4	
Moisture	7.2		

[a] Data from Minnesota Linseed Oil Co., 1968.
[b] Ref. 4, Chapter 17.
[c] Ibid. Chapter 14.

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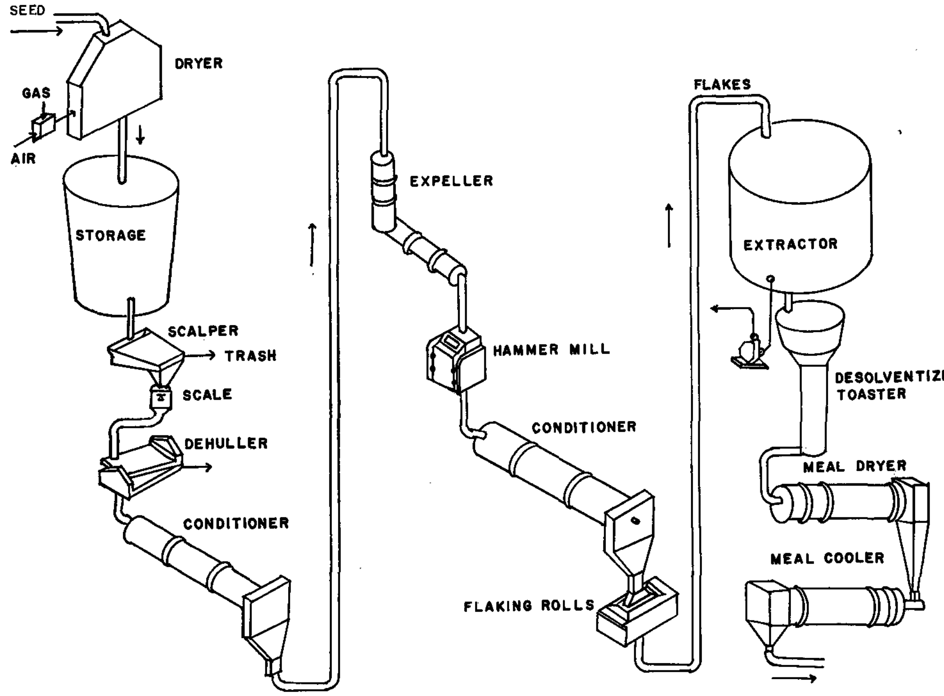

FIG. 2. Flow chart of prepress sunflower plant.

ment modifications. Disadvantages are: a lower production rate, and higher residual oil content in the meal.

Prepress-Solvent Extraction Process

Most of the information for this process was supplied by Coop Vegetable Oils Ltd. of Altona, Manitoba, processors of sunflower oil for over 15 years by the prepress method.

Whole seed can be processed using expellers, but this discussion will be limited to processing dehulled seed. Figure 2 is a flow sheet for the process.

Dehulling

Since sunflower seeds contain 20–25% hulls, dehulling is one of the most important operations in the processing of sunflower seed. The process to be used is dependent upon the desired results, i.e., the amount of oil lost to hulls and the amount of crude fiber to be left in the meal. Wamble reporting on his pilot plant work (7), says that cottonseed oil mills will be able to do a good job of hulling and separating sunflowers with their present equipment, after some simple changes in speeds, metal sizes, etc. Coop Vegetable Oils, longtime sunflower processors have adopted a method which is simple, economical, and does a reasonably good job. They burn the hull fraction (containing less than 2% oil). The finished meal contains 42–44% protein and 12% maximum crude fiber. They use a disk huller. Figure 3 describes the separation equipment.

Increasing demand for edible protein combined with a large increase in sunflower seed processed will require changes and improvements in dehulling methods and utilization of the hull fractions. This may result in more equipment, more stages, and new techniques. No clear-cut data are available on the advantages of impact dehulling, attrition, or cracking rolls as a means of hull separation. Nine per cent seems to work well, but the combined effects of moisture and temperature variables is not well known. Sizing of the whole seeds would improve hulling efficiency, but to what extent is yet to be determined.

It is relatively easy to remove hulls down to the 7% level. To improve on this will take a great deal of experimentation under production conditions.

TABLE V

Analysis of Meal Products From Direct Solvent Extraction Process[a]

Product	Minimum protein	Minimum fat	Maximum crude fiber
44% Meal	44	3	8
16% Hi Pro roughage pellets	16	3	34
8% Lo Pro roughage pellets	8	3	55

[a] Data from Sun Plant Products Co., Gonvik, Minnesota.

Prepressing

Several operators have found expellers operate satisfactorily with dehulled seed at the 4–6% moisture level and at temperatures of 180–220 F (8). Table VI shows some typical expeller operating conditions for sunflower seeds under these conditions.

Expeller cakes must have moisture added to the level of 10–11% to provide good flaking material. Flakes should be .010–.012 in. thick to provide good extraction and to

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TABLE VI

Typical Expeller Operating Conditions at Three Mills

Operating conditions	Mill 1[a]	Mill 2[b]	Mill 3[c]
Temperature of feed	170–190 F		190–220 F
Moisture of feed	4–6%	5%	4–6%
Cake thickness	⅛ in.	⅛ in.	⅛ in.
Residual oil	15%	11%	16%
Vertical spacing, in./1000			
A	....	15	20
B	....	10	15
C	....	7½	15
Horizontal spacing			
A	15	7½	10
B	10	7½	10
C	7	10	10
D	7		

[a] Minnesota Linseed Oil Co.
[b] Coop Vegetable Oils Ltd.
[c] Anderson Clayton, pilot run.

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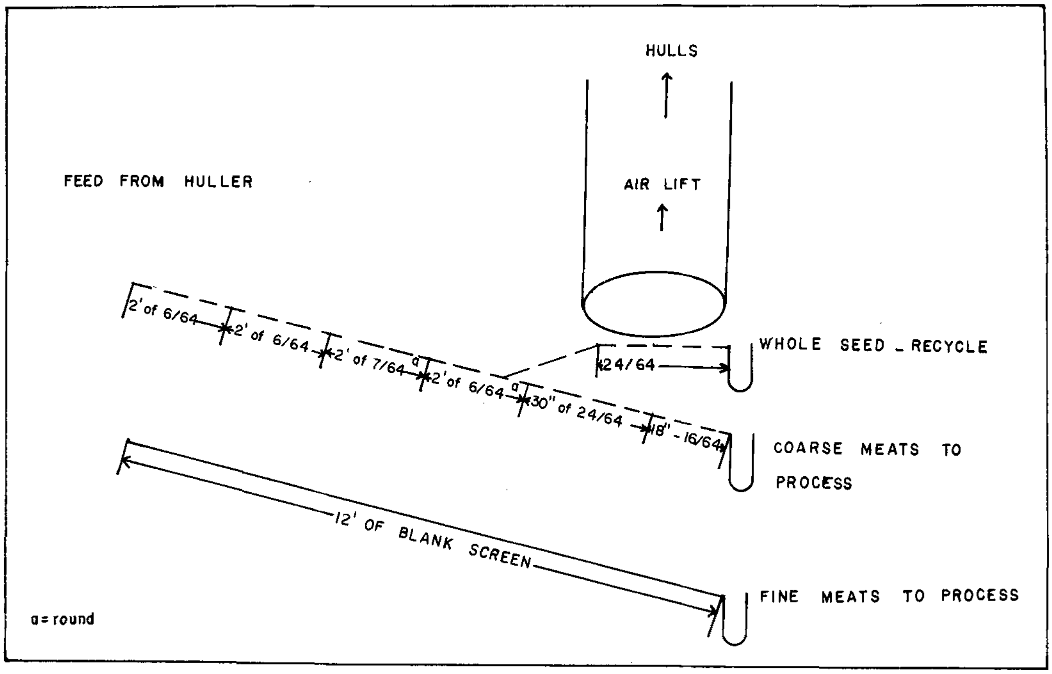

FIG. 3. Bauer separator equipped for sunflower separation.

mimimize fines plugging in the extractor. Mass flow conveyors should be used to convey the flakes to the extractor. Any of the various types of extractors probably will extract good flakes at the rated capacity for soybeans.

As with other oilseeds, care should be taken in desolventizing the flakes, to prevent lowering of the nutritional value of the meal. Temperatures of 180–190 F with little or no live steam are preferred if a desolventizer-toaster is used.

The oil should be treated with the same care as other oils. Excessively high still temperatures will damage the oil.

Table VII shows a typical analysis of products from the prepress method of processing.

TABLE VII
Analysis of Meal Products From Prepress Process[a]

Products	Protein, %	Fat, %	Crude fiber, %
44% Meal	44	1.0	12
hulls	4	1.5	50

[a] Data from Coop Vegetable Oils Ltd, Altona, Manitoba.

The advantages of this process are higher plant capacity and higher production rates with lower residual oil content in the finished meal. The fines content of material going to the flaking rolls is less critical. Cottonseed and flax seed processors can effectively use much of their existing equipment with relatively slight modifications and additions.

ACKNOWLEDGMENTS

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ABSTRACTS: FATS AND OILS

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at intervals: acid value, peroxide value, carbonyl value, induction period by the Warburg apparatus, and fatty acid composition of the oil by gas chromatography. These values did not change much when stored at 25C up to 60 days. Their changes were remarkable, however, when stored at −5C or at −25C. Fatty acid composition did not change so much. Some precipitate which appeared at −5C storage was mainly more saturated triglycerides than those contained in original oil. In conclusion these tests were not appropriate to detect the early stage of deterioration of oil at low temperature.

MELTING POINTS OF EDIBLE SOLID FATS. III. OPEN-TUBE MELTING POINTS OF LAURINE OILS. Isao Niiya, Hiroshi Iizima, Masao Imamura, Masakazu Okada and Taro Matsumoto (Japan Margarine & Shortening Makers Assn., Nihonbashi, Chuo-ku, Tokyo, Japan). *Yukagaku* 18, 741–6 (1969). Coconut and palm-kernel oils and their hardened oils were examined on open capillary mp, polymorphism, and solid fat index after 1, 5, 24, 120, and 1440 hr at 0, 10, 20, 30, and 40C. Coconut oil showed larger difference in mp with increasing temperature of standing. Polymorphism was limited to the β' type. Hardened palm-kernel oil showed greater difference in mp due to the temperature of standing than coconut oil. Palm-kernel and its hardened oils showed β'-3 type in addition to β', under certain conditions.

IDENTIFICATION OF FLAVOR COMPOUNDS IN FATS AND OILS. I. Yoshiyuki Kawase, Yoshio Ohta, Harumi Niizuma and Kosaku Yasuda (Nisshin Oil Mills, Kanagawa-ku, Yokohama, Japan). *Yukagaku* 18, 738–41 (1969). Refined, deodorized cottonseed oil (peroxide value 0.35 mEq/kg) was formulated into mayonnaise, which was then aged in an oven at 40C for 4 weeks.

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