Results achieved by the "Direx" process

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Direct extraction of oilseeds without resorting to prepressing

In the oils and fats industry, oilseeds with high oil content are usually extracted in two stages: pretreatment and pressing, and solvent extraction of the residual oil contained in the expeller cakes. Modern oil technology has long been pursuing a method capable of extracting oilseeds by a single process. The incentive to such research originates from the fact that the oilseed pretreatment and pressing involves heavy expenses in processing and maintenance costs of continuous expellers. Research carried out by C.M.B.'s Study Center, Pomezia, has led to a new process to directly extract oil contained in oilseeds, even if they have a high oil level. This process consists of a single solvent extraction and makes use of two special continuous extractors assembled in series; the former exploits the percolation principle and the latter the immersion principle. This has the advantage of directly treating high oil content seeds, and as a result the conversion cost is lower than that required by today's processes. The following is illustrated by flowsheets, photos, and technical and economic data.

Oilseeds containing over 20% oil are usually subjected to a series of processes in order to extract the oil as far as possible. The conventional method used can be summarized as follows: After a pretreatment such as delinting, hulling and cleaning, high oil content seeds are reduced to small pieces by grooved roller mills; moisture is added to the desired level during heating in special conditioners, and then pressed in continuous expellers, where the mass of oilseeds is subjected to high pressures and reaches a temperature of 160-180 C. Under these conditions, most of the oil is extracted.

When the pressing process is not thorough, a 16-18% residual oil remains in the cakes (prepressing); if it is carried out thoroughly, the oil level drops to a value of 6-8% (pressing). The oil thus extracted is extremely rich in mucilages, seedmeal and small seed fragments which slip out of the pressing cage; this oil is usually decanted in continuous settling tanks and then filtered through filter presses to be purified.

Oil cakes leaving continuous expellers are broken by cake crushers and then flaked in large, smooth roll mills which reduce them to small flakes only a few tenths of a millimeter thick. The flaked material is conveyed to the solvent extraction plant where nearly all the oil contained in the cakes is recovered.

To better explain the technological success achieved by the "Direx"® process, it would be useful to analyze the physical phenomena which take place during the extraction of oil from seeds. If we grind high oil content seed into 1-2 mm thick pieces and then solvent extract them, we observe that only part of the oil has been extracted, namely the one which has freed itself from the oil cells, during the grinding process. If, instead, we grind the same seeds in a similar manner, heat and moisten them under controlled and programmed conditions and submit them to the expeller process, we notice that a quantity of oil higher than that extracted by the solvent extraction process comes out of the mass of seeds. This is due to the fact that during the heating, moistening and pressing stage many other oil cells opened with the oil coming out easily under the action of pressure and temperature.

If we now crush the expeller cakes and solvent extract them, we notice that here too it is impossible to extract all the oil because of the many oil cells still unbroken. To minimize (0.5%) the oil contained in meals leaving the solvent extraction plant, the crushed cakes must be flaked so as to break the intact oil cells still present.

In the light of all these physical phenomena, we should come to the conclusion that it is impossible to extract the whole fatty matter contained in the seeds rich in oil by only the solvent extraction process. Yet, if we follow the processing cycle "Direx," developed by C.M.B., Pomezia, Italy, we see that the operating principle upon which the new process is based is as follows: If we grind the seeds rich in oil into 1-2 mm thick fragments and subject them to a cold percolation-type solvent extraction process, we observe that, after desolventizing, their oil content has dropped from 40-50% to 14-16%. If we reduce these seed fragments, still hot as they leave the desolventizer, into small flakes, by passing them through the large smooth rolls of a standard flaker and submit them to a second solvent extraction process of the immersion type, we notice that, after further desolventizing, their oil content has dropped to values of 0.4-0.6%.

The physical phenomena which take place during the "Direx" process can be summarized as follows: (1) During the first stage of solvent extraction by percolation, almost all the oil which has escaped from the oil cells during the cold grinding process has been extracted. (2) During the desolventizing process of the meal generated by the percolation extractor, many of the still unbroken oilcells burst by explosion. (3) During the subsequent flaking process of the desolventized meal, all the remaining unbroken cells are split by flakers. (4) During the second stage of solvent extraction by immersion, the residual oil contained in the meal is easily extracted.

To confirm this reasoning, we list a series of experimental data obtained at C.M.B.'s Research Center when processing oilseeds such as rapeseeds, peanuts and sunflower seeds.

The operating cycle was as follows: (1) Oilseeds were cold-ground (21 C) by a grooved roller mill; sunflower

TABLE I

Breakdown of Consumption Related to the Processing of Five Metric Tons of Hulled Sunflower Seeds Per Hour

Processing capacity: 5 tons/hr of seeds with 50% oil	With prepressing[a]				"Direx"[b]			
	Power, kwh	Steam, kg	Water, m^3	Solvent, kg	Power, kwh	Steam, kg	Water, m^3	Solvent, kg
Roller mill for 1st grinding	12	---	---	---	12	---	---	---
Cooker for expeller	12	500	---	---	---	---	---	---
Continuous expeller	130	---	---	---	---	---	---	---
Settling tank	3	---	---	---	---	---	---	---
Oil filter and pump	3	---	---	---	---	---	---	---
Cake breaker	8	---	---	---	---	---	---	---
Flaker	35	---	---	---	35	---	---	---
Solvent extraction plant	40	1500	49	20	45	2200	56	25
Conveying equipment	18	---	---	---	12	---	---	---
Total	261	2000	49	20	104	2200	56	25

[a]Man hours: plant, 4 hr; maintenance, 1 hr.
[b]Man hours: plant, 2.5 hr; maintenance 0.25 hr.

seeds were previously hulled. (2) The seed fragments were then passed through several sieves to obtain granules of a classified size. (3) The classified seed granules were extracted by an oil-solvent miscella, with a 12% oil concentration, in the percolation extractor for 40 min at a temperature of 45 C. (4) After the percolation extraction, the oilseeds were drained and desolventized at 105 C. (5) Following desolventizing, the oilseeds were reduced to thin flakes and passed through a smooth roll flaker. The latter was adjusted so as to obtain seed flakes of different diameter. (6) The oilseeds thus flaked were submitted to an immersion extraction process with pure hexane for a period of 120 min at a temperature of 45 C. (7) After the immersion extraction, the oilseeds were drained and desolventized at 105 C.

During this series of trials, continuous and thorough analytical checks, shown in Figures 1-3, were conducted. The data shown in these figures confirm that the extraction of oil from seeds, even with a high oil content, can be accomplished by the mere solvent process without resorting to the expensive expellers.

When comparing the two processes, it can be easily noticed that the "Direx" process is much simpler than the conventional one. However, since the superior performance and efficiency of a system can be appreciated on an industrial scale only by highlighting its economic advantages, a series of thoroughly checked technical and economic data is given (Tables I and II). These data support the following conclusions: (1) The seed prepressing process requires a much higher power consumption (31 kwh/ton). (2) The prepressing process entails a higher labor cost. (3) The steam consumption is somewhat higher when treating the seed with the new system (40 kg/ton). (4) The two processes require roughly the same water and solvent consumption. (5) The new "Direx" process requires a 27% lower capital outlay.

If we take into account a medium capacity plant capable of processing 120 metric tons oilseeds per 24 hr equivalent to 5 tons/hr, the new process of direct extraction has the following economic advantages over the conventional one (Table III).

TABLE II

Capital Outlay

Plant capacity: 5 tons/hr of high oil content seeds	Method of processing	
	With prepressing	"Direx"
Roller mill for 1st grinding	8,000,000	8,000,000
Cooker for continuous expeller	12,000,000	---
Continuous expeller	80,000,000	---
Settling tank	6,000,000	---
Oil filter	7,000,000	---
Cake crusher	2,200,000	---
Flaker	16,000,000	16,000,000
Conveying equipment	9,000,000	4,200,000
Extraction plant	130,000,000	169,000,000
Total price of equipment	Lit. 270,200,000	197,200,000

TABLE III

Conversion Costs

Plant capacity: 5 tons/hr high oil level seeds	Method of processing		
	With prepressing	"Direx"	Difference
Operating costs	443,088	310,272	132,816
Depreciation allowances	190,000	132,000	58,000
Total	663,088	442,272	190,816

Grade of extracted oils

The comparative tests carried out proved that the quality of the oil extracted by the new "Direx" process is better than that produced by continuous expellers for the following reasons: (1) In the "Direx" process the oil is solvent-extracted at a low temperature (maximum 45 C) whereas in the pressing process the seeds reach, in the expeller cage, a temperature of 180 C. (2) The oil produced by the "Direx" process has a better color than that obtained with the conventional one, mainly because the latter requires high pressure and high temperature facilitating the passage of coloring matters from the seeds into the oil.

The "Direx" plant

After our analysis of the new process from a technical and economic viewpoint, it is proper to inform the reader how we managed to develop and improve the new industrial plant "Direx."

As mentioned in the theoretical description of the direct extraction process, two highly efficient extractors were needed to implement such process on an industrial scale; the former of the precolation and the

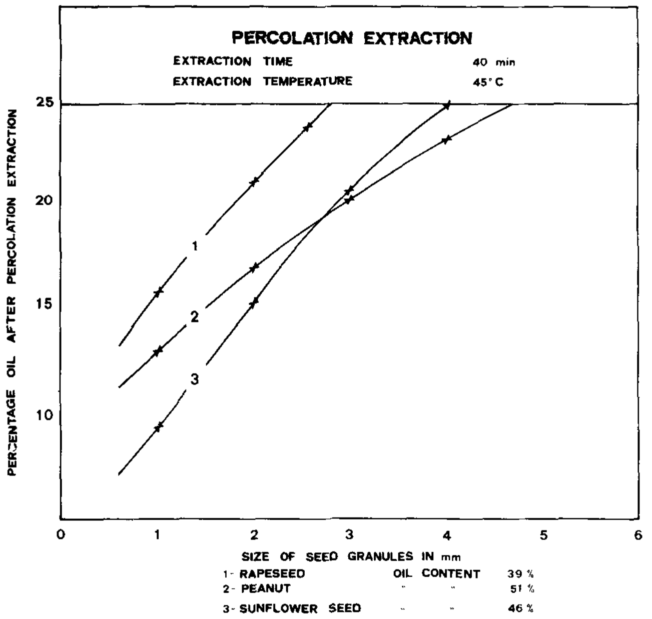

FIG. 1. Residual oil content in seeds after the grinding and percolation process in the various forms of granulometry. 1 = Rapeseed, oil content = 39%; 2 = peanut, 51%; 3 = sunflower seed, 46%. Percolation extraction time, 40 min; temperature, 45 C.

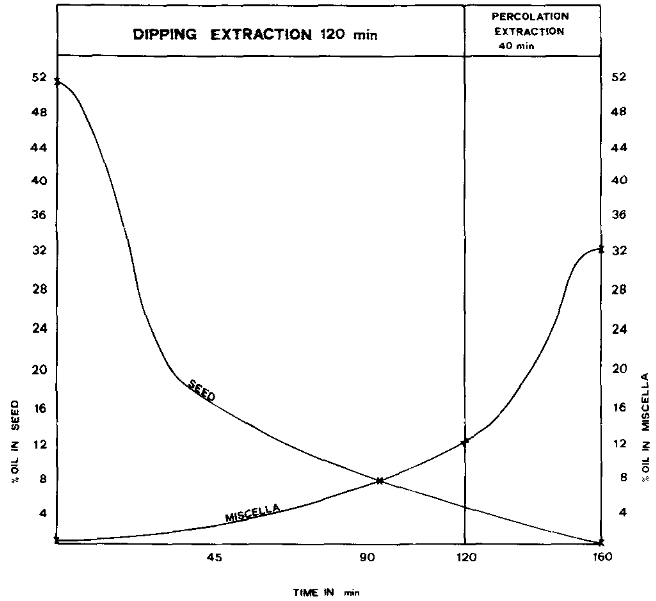

FIG. 3. Two curves indicating how the oil content of a seed varies (in this case peanut) when coming into contact with oil-solvent mixtures of different oil concentration during the "Direx" process.

latter of the immersion type.

The only unit capable of satisfying these requirements was no doubt the "Percolimm" plant manufactured by C.M.B. In fact, this plant consists of two extractors assembled in series, the former exploiting the percolation principle and the latter the immersion one, and its operation is as follows: After being flaked, oilseeds or expeller cakes enter the percolation extractor, are washed by solvent jets and then passed to the immersion extractor where they are rewashed by solvent in countercurrent fashion. The solvent covers the opposite path, i.e., it enters the immersion extractor, passes in countercurrent through the bulk of seeds, leaves the immersion extractor and is recycled to the percolation extractor by a set of pumps.

This plant has the following advantages: (1) Solvent-oil mixture very rich in oil; (2) Possibility of processing also oilseeds and cakes with an oil content as low as 25%; (3) Very low residual oil in the extracted meal; (4) Possibility of processing small-sized and fine meals.

The availability of such a dual extractor plant enabled C.M.B. to realize a plant capable of directly processing high oil content seeds without resorting to continuous expellers, according to the principles set out in the first part of this paper. Figure 4 shows the scheme of this new extraction plant which has been designed and already built on an industrial scale by C.M.B.

As can be easily noticed, the only difference between the two processes lies in the additional meal desolventizer installed in the new plant. The operation of the "Direx" unit is as follows (see Fig. 5). The seeds are reduced into small pieces by a roller mill and conveyed to the percolation extractor (1). By passing through a batcher and covering all the extractor ring, they are automatically discharged into the first meal desolventizer (2). During this passage the seeds are washed by jets of solvent-oil mixture (percolation) coming from the immersion extractor. Such miscella is recycled to the process by a group of

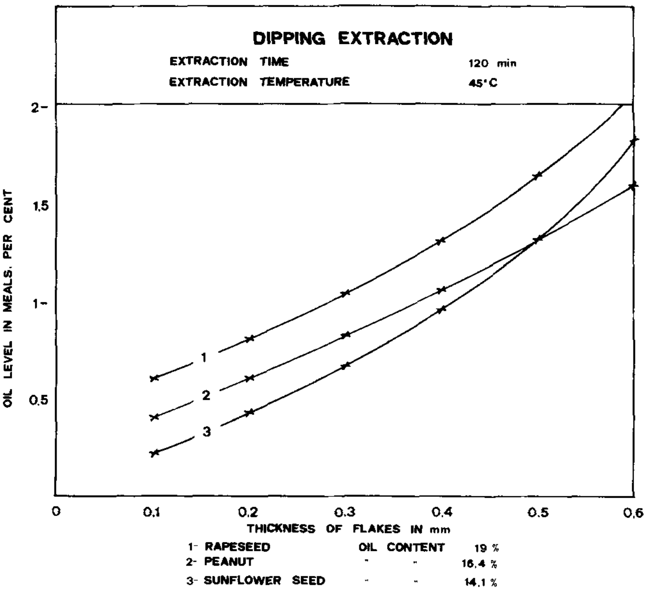

FIG. 2. Residual oil content in deoiled meals after oilseeds have undergone the percolation, flaking and final immersion extraction processes in the different forms of flaking. 1 = Rapeseed oil content = 19%; 2 = peanut, 16.4%; 3 = sunflower seed, 14.1%. Dipping extraction: time, 120 min; temperature, 45 C.

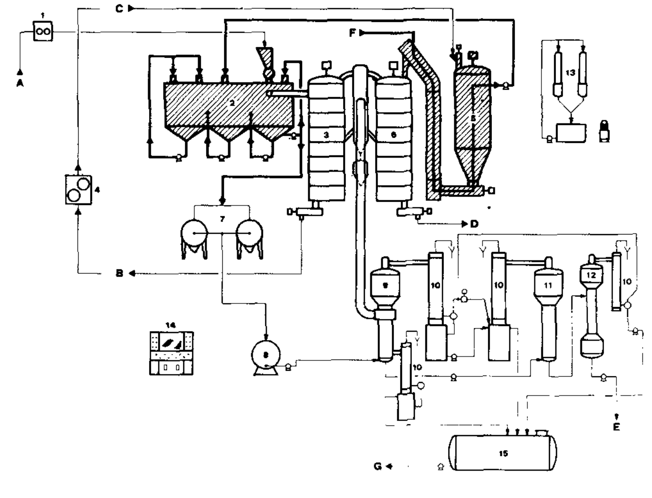

FIG. 4 Complete scheme of the "Direx" plant. 1, Roller mill; 2, percolation extractor; 3, 1st meal desolventizer; 4, flaker; 5, immersion extractor; 6, 2nd meal desolventizer; 7, rotary miscella filters; 9, miscella preconcentrator; 10, condensers; 11, miscella distiller; 12, stripping column; 13, solvent-gas recovery unit; 14, electrical control board; 15, solvent tank; A, seed inlet; B, outlet for partially deoiled meal; C, flaked meal inlet; D, deoiled meal outlet; E, extracted oil outlet; F, solvent inlet; G, solvent recycling. (Permission of C.M.B., Pomezia, Rome.)

TABLE IV

Data Obtained at Federacao de Evora

Technical data		Service consumptions related to 1 metric ton of seeds processed[a]	
Quantity of seeds treated in 24 hr	120 metric tons	Steam	455 kg
Average oil content in seeds	40.1%	Power	20.8 kwh
Average oil content in seeds after percolation extraction	16.7%	Process water (when cooled and reused)	1 m^3
Average oil content in meal after immersion extraction	0.41%	Solvent	5.5 kg
Oil concentration in the miscella leaving the immersion extractor	11.6%		
Oil concentration in the miscella leaving the percolation extractor	30.2%		

[a]Total service consumptions including grinding, percolation extraction, flaking and immersion extraction.

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pumps in such a way that the miscella with a higher oil concentration comes in contact with the higher oil content seeds. Under these conditions an extremely oil-rich miscella is obtained. The meal, which still has an oil content of 14-18%, enters the first desolventizer (2), where it is desolventized and then conveyed to the flaking room. The flaked meal is conveyed to the immersion extractor (3) and countercurrently washed by solvent (immersion). During this process the meal is completely deoiled. The meal is collected by an elevator, drained and conveyed to the second desolventizer (4) where the solvent is completely removed.

The solvent runs inversely: it enters the elevator, countercurrently passes through the meal flowing down along the axle of the immersion extractor, is sucked by a pump and recycled to the percolation extractor (1). The miscella leaving this extractor has a very high oil concentration. It is passed onto the filtering section and is then distilled in order to separate the oil from the solvent.

Technological data

Table IV collects a series of data obtained at the factory of the Federacao de Evora, Evora, Portugal, when our "Direx" plant was processing safflower seeds.

The most outstanding features of this plant lie in the simple processing method and smooth operation. The advantages of the new "Direx" process over the expeller one may be summarized as follows: (1) simple construction and operation with minimum floor space requirements; (2) extraction of all the oil contained in the seeds by a single plant and without resorting to expellers; (3) very high oil concentrations in the miscella after extraction; (4) substantial savings in operating expenses and depreciation allowances; (5) cut in capital outlay; (6) lower labor costs and (7) excellent quality of extracted oils. We therefore conclude that the new process will soon be widely used on an industrial scale, thus rendering continuous expellers obsolete.

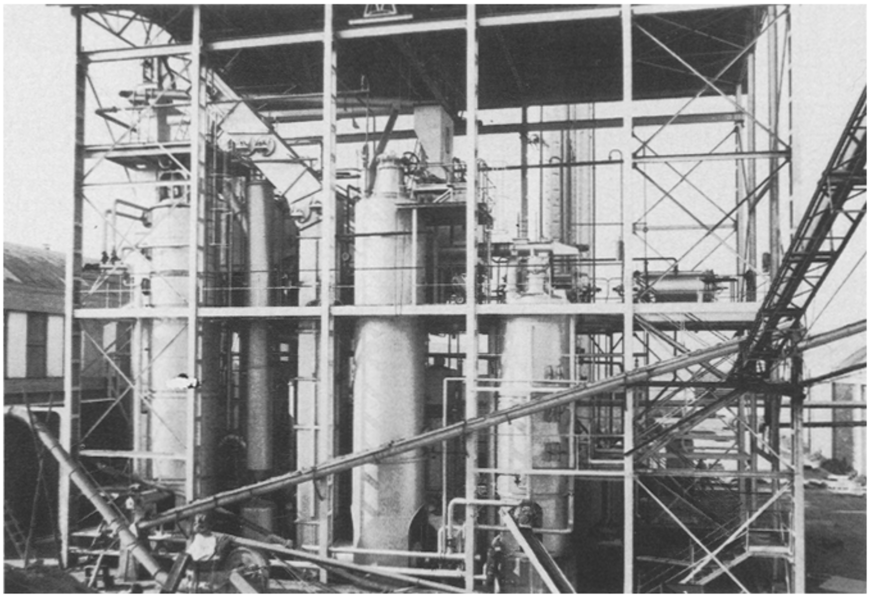

FIG. 6. "Direx" plant: processing capacity 100 metric tons per 24 hr. (Permission of Federacao de Evora-Evora, Portugal.)

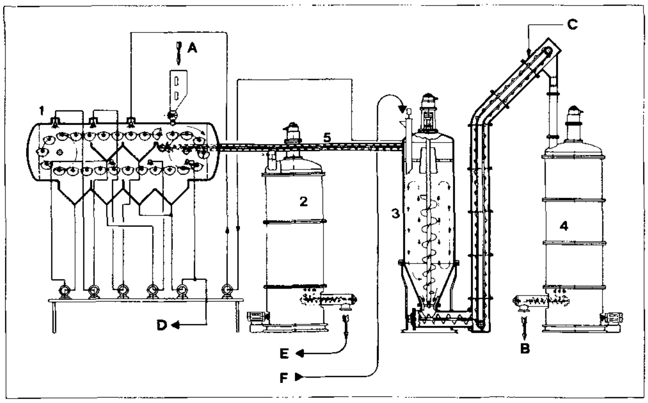

FIG. 5. Scheme of the dual extractor "Direx." 1, Percolation extractor; 2, 1st meal desolventizer; 3, immersion extractor; 4, 2nd meal desolventizer; 5, bypass; A, seed inlet; B, meal outlet; C, solvent inlet; D, outlet for solvent-oil mixture; E, seed to flaking; F, seed from flaking. (Permission of C.M.B., Pomezia, Rome.)

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