•Sunflowerseed Extraction with a New Type of Extractor

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ABSTRACT

In this study extraction of sunflowerseeds is performed using a new extractor system which eliminates various operations, such as dehulling and prepressing, of the conventional systems. This new extraction system uses a moving bed of seeds which is continuously washed with fresh solvent sprayed from mobile spray nozzles. To confirm the performance of the Gülbaran extractor for extraction of sunflowerseeds, the effects of extraction temperature, residence time, solvent/meal ratio and particle size on the oil yield are investigated.

The experiments performed showed that the optimum extraction conditions are 50-53 C solvent temperature, 40-45 C extractor temperature, 90 min extraction time, 2.7 kg/hr solvent flow rate and 0.9-1.0 mm particle size. The resultant miscella in this system was more dilute than some multicell extractors, thus requiring more evaporator costs.

INTRODUCTION

Recently, there has been a steady increase in the production of various oilseeds and vegetable oils in Turkey. The total production of vegetable oils grew from 215,000 to 285,000 tons from 1977 to 1982. Sunflowerseed production increased from 200,000 tons in 1966 to 800,000 tons in 1982 (1). There is a potential for improvement on this figure because inefficiency in Turkish agriculture presently lead to low yields and there is more area that may be allocated for sunflower and the other oilseeds. Keeping these factors and the country's plans to increase agricultural output in mind, the oilseed industry in Turkey needs to face new challenges.

So far, sunflowerseed processing in Turkey is done by three different methods, namely, pressing, batch solvent extraction and prepressing-solvent extraction. Operational and economic aspects show diversities among these three methods and in every method in itself.

In general in Turkey three types of extractors, De Smet, Lurgi and Rotosel, are in operation. These are developed abroad and imported to the country. Therefore, efforts to design and develop a new type of oilseed extraction system which will meet the needs of the country are of paramount importance. For this purpose development of a new type of multipurpose extractor has been attempted. This new system also has been applied to the extraction of linseed and rapeseed oil (2,3). In this study its application to extraction of sunflowerseed has been done. Also, studies are being carried out to assess the feasibility of this new system on sugar beet extraction (4).

Solvent extraction processes in theory vary considerably depending on parameters such as the type of solvent, extraction temperature, flake thickness, type of raw material and its characteristics and contacting system (5-9).

For a designed system the extraction process may be controlled by one or a combination of diffusion, solubility and dialysis (10). A proper choice of design parameters may favor one particular controlling step. The Gülbaran extractor system originally was designed for sugar beet extraction and patented in Germany and the United States (11,12). In this design, the temperatures of the solvent and the seed are kept a few degrees below the boiling point of the solvent so that high solubility and diffusion rates are obtained. The high temperature operation in the extractor also affects the solvent flow through the bed because during the process of extraction the concentration increases; this increase is a function of temperature together with viscosity and density.

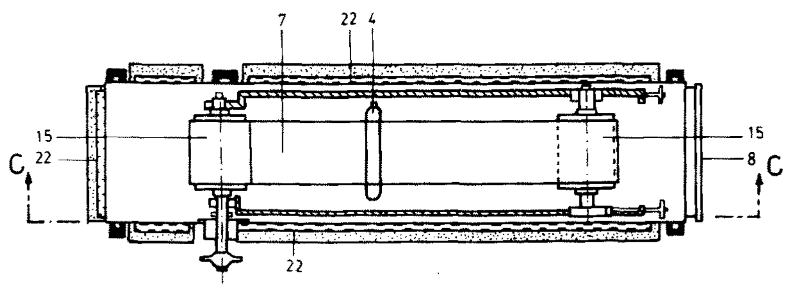
Oilseeds containing over 20% oil usually are subjected to a series of pretreatment such as delinting, dehulling and cleaning. High oil content seeds are reduced to small pieces by grooved roller mills, conditioned and then pressed in continuous expellers at high pressure. This process may be carried to prepressing or pressing level which correspond to typical oil levels of 16-18% and 6-8%, respectively (13). The remaining oil is extracted by solvent extraction. The Gülbaran diffuser is an attempt to develop a continuous single-stage crosscurrent oilseeds extraction technology. It is designed to be versatile so it could be applied to the extraction of various seeds growing in Turkey with very little change.

The second aim of the Gülbaran design was the omission of prepressing or pressing, which constitutes an important part of the operational costs in conventional systems. In order to extract the oil under these conditions with low residence times and high extraction yields, fresh solvent without any recirculation is used.

EXPERIMENTAL PROCEDURES

The Gülbaran extraction system consists mainly of a rolling mill which has two pairs of cylinders, a percolation type extractor, solvent and water heating vessels, screw conveyor and miscella recovery system (14). The layout of the extraction system and the details of the extractor are shown in Figures 1 and 2.

The application of the system to sunflowerseeds may be summarized in the following sequence: received seeds are first cleaned using a sieve. The cleaned seeds are fed to a rolling mill with two pairs of cylinders in which the first, corrugated rolls are stacked on top of another rolling mill with a pair of smooth rolls, running against each other on a horizontal plane. Then the crushed and flaked seeds are preheated and pass to the extraction stage, using a screw conveyor with a hot water jacket. The seeds fall on a moving belt type of conveyor forming an average bed height of



[a]Deceased.

FIG. 1. Top view of extractor.

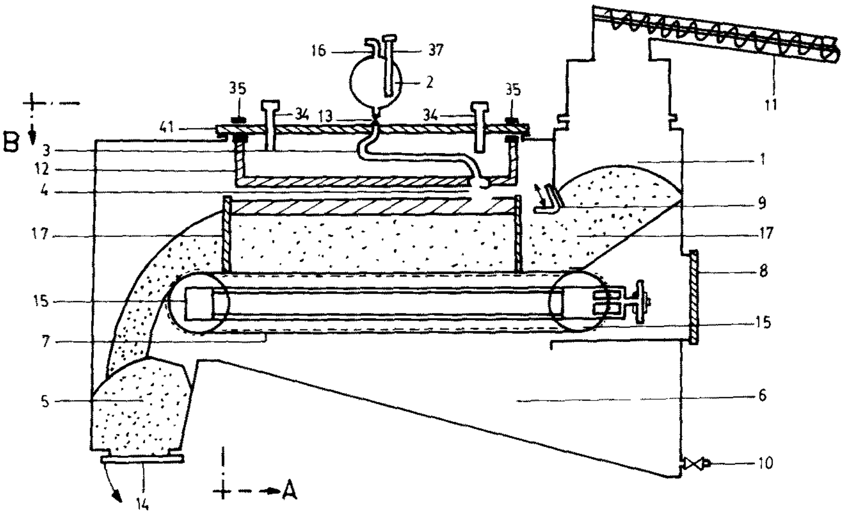


FIG. 2. Front view of extractor. 1, feed; 2, solvent tank; 3, heated solvent feed pipe; 4, spray feeder; 5-14, meal discharge; 6, miscella; 7, conveyor; 8, man-hole; 9, level control; 10, product; 11, screw feeder; 12, feeder drive; 13, globe valve; 15, cylinder; 17, bed; 22, jacket; 34-37, thermometer; 35, disc; 41, cleaning valve.

20 cm, which was found to be the optimum height in a previous study (15). During the course of extraction the moving bed of seeds is washed continuously with fresh hexane sprayed from mobile spray nozzles. The solvent is fed from the vessel at 60 C, which is close to its boiling point. After a predetermined extraction time, miscella is transferred to the solvent recovery system and the meal is recovered for experimental considerations. All items in the Gülbaran extractor that contact solvent, miscella or oil are made of type 304 stainless steel. The extraction time can be varied from 30 to 120 min.

In this study, in order to assess the performance of the Gülbaran extractor for extraction of sunflowerseeds, the effect of extraction temperature, residence time, solvent/meal ratio and particle size on the oil yield were investigated.

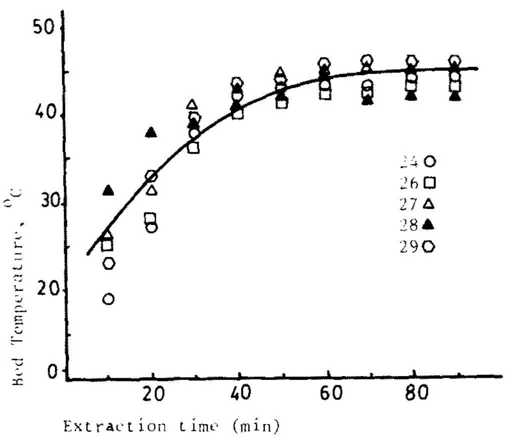


FIG. 3. The change in bed temperature with extraction time.

RESULTS

Effect of Particle Size

Prior to the evaluation of the three chosen parameters of temperature, residence time and solvent flow rate, the effect of average particle size on the oil yield was determined on fresh seeds. In the interval 0.84 to 1.24 mm, oil yields did not change substantially for average particle sizes smaller than 0.90 mm. Therefore, in the ensuing sections the experiments are done using an average particle size of 0.90 mm.

Effect of Extraction Temperature

Under normal operating conditions the bed material was heated by the incoming solvent, and the temperature rose from room temperature to 45 C in about 60 min (Fig. 3). It is well-known that the extraction yield would be better at temperatures close to the boiling point of the solvent. Therefore, in the ensuing runs the bed material was preheated using a hot water jacket. The results of these batch runs are shown in Table 1.

TABLE I

Effect of Extraction Temperature

Exp. No.	Oil content of oilseed	Solvent/Oilseed	Extraction time (min)									Oil content of meal	Recovery of yield
			10	20	30	40	50	60	70	80	90		
1	%	kg/kg	Bed temperature, °C									%	%
1	45.97	3.5/1	19	28	38	42	48	42	41	44	45	1.5	98.38
2	45.10	4.5/1	25	28	36	40	42	42	42	43	43	1.23	98.64
3	43.94	4.5/1	27	32	40	43	44	44	45	45	45	0.9	98.99
4	44.95	4.5/1	32	38	39	41	41	41	42	41	41	1.23	98.64
5	44.88	4.5/1	32	33	34	42	42	40	40	41	41	1.47	98.35

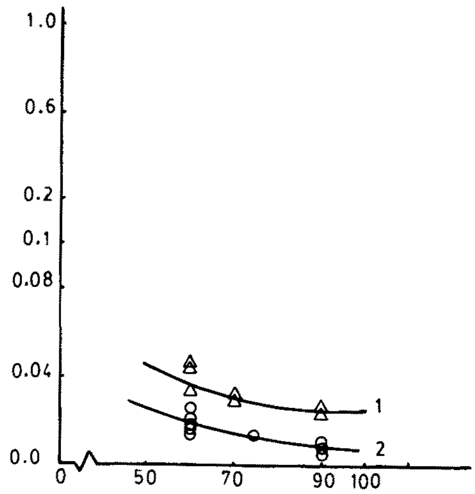


FIG. 4. The amount of oil remaining in the seeds with the extraction time.

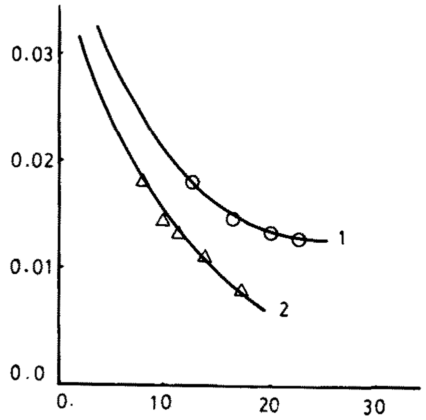


FIG. 5. The effect of sunflowerseed aging on extraction yield.

Optimum Residence Time

Because all the experimental runs are carried at a constant bed height of 20-25 cm (15), the residence time was the sole means of controlling the capacity. However, the capacity should not be expected to sacrifice from the oil yield. Therefore, the effect of extraction time on the yield is investigated for two different solvent flow rates.

The results of these experiments are shown in Figure 4. From these figures it has been observed that for both runs the oil content of the meal reaches to a limiting concentration asymptotically at about 90 min. For the rest of the runs optimum residence time is taken as 90 min.

Effect of Solvent Flow Rate on the Yield

In these experiments particle size, extraction temperature, bed height and residence time are taken as constants at their optimum values, and solvent/meal raw material ratio is taken as parameter. Experiments are carried out for newly obtained and yr-old seeds. The results for these experiments are shown in Figure 5. For the aged seeds, residual oil in the meal reaches a minimum value at about 25 kg/hr solvent flow rate. Under similar conditions for new seeds much lower residual oil is left in the meal.

DISCUSSION

In this study sunflower seeds containing 40-45% of oil were extracted by using a single cell cross current flow extractor. The oil in the resultant meal is reduced below 1%, which is acceptable efficiency at extraction plants currently operating in the oilseed industry. The main features of this system as compared to conventional systems, especially in extraction of seeds containing more than 20% oil, is the elimination of prepressing in the pretreatment stage of oilseed extraction. In addition, cookers, settling tanks, filterpresses and the secondary crushing of pressed meal are eliminated. Also dehulling, which is an essential part of a prepressing extraction system, is not used. In the present system sunflowerseeds are only crushed and pressed and heated 40-45 C before the solvent extraction stage. According to the experimental results given in the previous section, the optimum extraction conditions are found to be: 50-53 C solvent temperature, 44-45 C extractor temperature, 90 min extraction time and 2.7 kg/hr solvent flow rate.

The Gülbaran diffuser works on fresh solvent and consequently on the resultant miscella tends to be dilute compared to some multicell extractors. For this reason one expects higher solvent evaporation costs.

The distinct change in the extraction yield of fresh and aged seeds is due to the deterioration of the oilseeds caused by certain enzymes in presence of moisture (16). This is a continuation of the natural fat production process of the plant during storage.

Approximately 29-30% protein is found in the unskinned cake obtained in the Gülbaran system. In the sieve analyses, 25-30% of the cake can be separated as skin fraction. Under these conditions, the percentage of protein in the cake is increased up to 36-42%. Thus, it is seen that the cake obtained in the Gülbaran system, compared to the cake obtained in the conventional systems, with respect to the percentage of protein included, is suitable for use by the fodder industry.

In conclusion, in this study it has been proven that sunflowerseeds having an oil content of 40-45% may be extracted with one stage direct solvent extraction such that the residual oil content in the meal would be reduced to 1% which is acceptable for practice.

In this way prepressing and related operations, such as cooking, settling filter pressing and dehulling, which are generally used by the current oil extraction industry, are omitted.

ACKNOWLEDGMENTS

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REFERENCES

1. The Fourth Five-Year State Development Planning, State Planning Organization, Ankara, Turkey, 1979.
2. Şaşmaz, D.A., Extraction of Rape Seeds in a New Extraction System, Ph.D. Thesis, Istanbul Technical University, 1980.
3. Şatiroğlu, K.N., Extraction of Flax Seeds in a New Extraction System, Ph.D. Thesis, Istanbul Technical University, 1982.
4. Altiner, A., Extraction of Sugar from Sugar Beets, ITU Der., 40:2, 16-22 (1982).
5. Othmer, D.F., and J.C. Agarwal, Chem. Eng. Prog. 51:372 (1955).
6. Wingard, M.R., and R.C. Phillips, JAOCS 28:149 (1951).
7. Coats, H.B., and M.R. Winward, JAOCS 27:195 (1950).
8. Ayerbe, F.R., Grosos Aceites 20:85 (1969).
9. Türkay, S., D.A. Şaşmaz, K.N. Şatiroğlu, and E. Ekinci, Proc. I. Nat. Design Congr. Istanbul, 1982.
10. Becker, W., JAOCS 55:469 (1978).
11. Gülbaran, E., U.S. Pat. No. 3,135,631.
12. Gülbaran, E., Bundenrepublik Deutschnland, Patent No. 1,024,269.
13. Stein, W., and F.W. Glaser, JAOCS 53:283 (1976).
14. Türkay, S., Extraction of Sunflower Seeds in a New Extraction System, Ph.D. Thesis, Istanbul Technical University, 1980.
15. Gülbaran, E., and H.S. Gülbaran, JAOCS 58:729 (1981).
16. Larmour, R.K., H.R. Sallans and B.M. Craig, Can. J. Res. 22:1 (1944).

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