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OIL SEED PROCESSING TECHNOLOGY IN PAKISTAN

Part I. State of the Art

Din Muhammad, Khizar Hayat Khan and Shafiq Ahmad Khan

PCSIR Laboratories Lahore

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The oil seed processing technology as existing in Pakistan, has been surveyed and reviewed. It has been observed that there are about ten thousand animal-driven kohlu units, almost two thousand five hundred power-operated large expellers and two thousand mini-expellers and fourteen solvent-extraction units processing various oil-bearing materials in the country. A quantitative treatment of the data concerning this technology, both traditional as well as modern, is described.

INTRODUCTION

Historical Background. The crushing of oil seeds for recovering oil is one of the oldest technologies of the world. Its origin can be traced back through several thousand years to the ancient civilisation of the Orient. The Chinese were first people to extract oil from seeds [1]. The Egyptians, as far back as the year 3000 B.C. knew how to obtain olive oil from olives. The equipment consisted of a press composed of a sausageshaped rush bag slung between the vertical posts of a strong wooden frame [2]. The bag when twisted by inserting a rod and wringing it squeezed the oil from olives, just as juice can be expressed from grapes. In the 19th century, when the ruins of Pompii were excavated, a large pestle and mortar was also found indicating the existance of an oil mill in those times.

In the ancient orient, the equipment of an oil mill consisted of a long pole that acted as a grinding pestle and a hollowed trunk of a tree as a mortar which held the seeds. An ass or an ox walked around the press, dragging the top and of the long pole and thus grinding the seeds in the hollowed tree trunk. The present Pakistani kohlu, in principle, follows the same pattern. The Pakistani kohlu has survived till today because of its operational effectiveness end simplicity in design, and is, therefore, being widely used in the country-side.

In kohlus of this type because of less pressure being applied, the oil yield is low. Further this type of mill is only useful for the expression of oil from soft oil-bearing materials. Seeds with hard testa are now also available which require greater pressure for oil expression. In the modern mill this has been achieved through the use of various types of high pressure oil expellers available in the market. In the early years, expression of oil from oil-bearing materials was done by a press employing a windlass and then by using a water-mill or wind-mill. Many improvements in the mill equipment have since been made and it is now possible to extract oil from all kinds of oil seeds.

Historically speaking, however, the improvements and design of the oil mill appeared during the 17th and 18th centuries, beginning with the hydraulic press of Joseph Bromah [3]. Many changes in the original hydraulic press were also made during the early 1900s. The idea of a mechanical press, conceived by V.D. Anderson in 1876, became the basis of an expeller [4]. The present-day expeller with various improvements and modifications of the Anderson machine, is now considered a standard oil expeller in almost all the oil mills. The oil extraction technology of the ancient times has thus come a long way and the modern machines are much more efficient and sophisticated.

The first mechanical screw press was successfully operated back in 1906 [5]. However, the manufacturers have attained remarkable measure of success, with improved materials of construction and manufacturing methods. Research and development activity has increased the efficiency of the scew press with the result that the range of such presses presently being offered to the oil-

milling industry can meet the requirements of the processors whether it be the capacity or the residual oil in cake. Similar presses of local as well as foreign origin are in use in Pakistan for expressing oil from different seeds.

Before describing the state of art, it will be appropriate to review the oil seed resources alongwith their processing in Pakistan.

Oil Seed Resources of Pakistan and their Processing

a) *Conventional Sources*

1. *Crops:* The main oil seed crops of Pakistan are cotton and various cultivated varieties of crucifers commonly called rape and mustard seeds. Groundnut, sesame and lin seed are also grown to a limited extent, but they are mainly used for edible purposes and seldom processed for oil extraction. In the villages, only mustard and rape seeds are processed by kohlus whereas all the cotton seed is processed with the help of expellers for the recovery of oil [6]. The acreage and production of the major oil seed crops of Pakistan are shown in Table 2.

All the cotton seed produed in the country is expressed by the high pressure expellers at different mills. The dehulling and delinting facilities are available at the solvent extraction units but only a small amoutn of the seed is so extracted. The recovery of oil from rape seeds is, however, evenly divided between the kohlus at the village level and the locally fabricated expellers at the town and city levels.

The solvent extraction units extract the dehulled and delinted cotton seed and the oil cake from the milled repe seeds. Some quantity of rice bran is also solvent extracted at Muridke, Faisalabad and Kotri.

A large gap exists between the supply of vegetable oil and its demand in Pakistan. The local production is insufficient mainly because of the non-availability of adequate quantity of oil seeds.

Like many other agricultural crops, the per acre yield of oil seeds in Pakistan is rather low and consequently the quantity of oil is far short of demand. It is reported that the total requirement of vegetable oil in the country is about 650,000 tons per year for edible purposes alone [7]. The domestic production of vegetable oil has almost remained stationary at about 200,000 tons per annum, contributed almost equally by rape seed and cotton seed expression. The remainder is being imported in the form of palm oil and soyabean oil to fill the gap at an estimated cost of about rupees 2–5 billion per year. These imports have been steadily increasing at a rate of about 15% per year because of the increasing demand due to population growth and increased standard of living of the people.

The agricultural research institutes have accelerated their efforts to introduce high-yielding varieties of oil seeds crops, in addition to new crops like sunflower, safflower and soyabean to bridge this gap. After extensive tests in the Punjab, Sind and NWFP, the cultivation of these crops have given good results. A new variety of sunflower (HO-1) has been cultivated successfully which gives a yield of 750 kg of oil seeds per acre. Another variety (S-79), yielding 675 kg in 80 days, has also been developed. Among safflower varieties. "Gilla" has given a yield of 1312 kg per acre, with 30% oil content [8].

Cultivation of olive plants and groundnuts in the area north of Jehlum must also be seriously considered as these two crops have big potential for those areas of the country where conditions are more favourable for their cultivation. Being 'Barani' or rainfed areas, the people of these parts are not as prosperous as those of the canal irrigated areas. It is, therefore, hoped that on becoming aware of the value of these crops, the farmers in these areas could be easily motivated for cultivating these two oil crops. Successful experiments for the plantation of olive trees have already been carried out at Khairimurat in Attock and Rawalpindi districts and if more trees are planted, Pakistan would have a perennial source from which olive oil can be easily recovered [9].

b) *Non-Conventional Sources*

Because of favourable climate, a variety of other seed-bearing plants also grow in various parts of the country. However, no systematic programme has been chalked out to produce these plants on commercial basis. A number of these oil-bearing plants have been evaluated by scientists of the PCSIR who have assessed their potential and suitability for human consumption [10]. Table 3 summarises these studies. It appears that a sizeable quantity of high quality oil could be obtained from these non-conventional sources if adequate arrangements are made to collect the seeds. At the present time, little or no oil seed from these non-conventional sources is being processed. There may be an opportunity to introduce and expand this activity of recovering oil from seeds at the village level if a planned seed-collection programme could be established. Collection and processing of Neem seed for recovery of oil in India is an

Table 1. Comparative statement of equipment presently available in Pakistan.

Operating parameters and specifications

Processing Technology	Type of oil seed	Percentage of oil in seed		Pretreatment of oil seeds	Oil recovery		Capacity kg/24 hrs.	Efficiency		Operational time batch-wise	Percentage of oil in cake		Percentage of of moisture in cake	
		Range %	Average %		Range %	Average %		Range %	Average %		Range %	Average %	Range %	Average %
Kohlu	Rape seed	30-45	40	Clean seed cold hot extraction	29-34	32.20	72 kg	78.84-86	83.4	13 kg/4 hrs.	8.2–12	9.30	4.2–5.5	4.7
Mechanized Wooden Kohlu	Taramira	26-35	30	–do–	18.7-24.8	21.3	192	64–77	69.6	8 kg/hr.	8.8–12	10.7	9–12	10.5
Power Kohlu	Rape seed	30-45	40	–do–	30.8-34.7	33.4	810	82.5–86.5	84.9	13 kg/25 mints	8.2–11	9.18	4.2–5.5	4.7
Low Pressure Expeller-3"	–do–	30-45	40	–do–	30–35	32.7	468	77.8–81.7	80.46	Continuous	11.5–13.8	12.5	4.6–5.5	4.8
Low Pressure Expeller-4"	–do–	30-45	40	–do–	31.3–35	32.7	720	79–84.3	81.3	–do–	10.5–13.6	12.5	4.6–5.5	4.8
Low Pressure Expeller (half)	–do–	30-45	40	–do–	32.35	33.5	950	84.9–87.5	85.6	–do–	8–9	8.5	4.2–5.5	4.6
Low Pressure Expeller (Std)	–do–	30-45	40	–do–	30–36	34	2000–2666	85.8–90	87.7	–do–	6–9	7.6	4.0–5.2	4.65
Low Pressure Expeller (Std)	Cotton seed	16-20	17.5	Not dehulled seed	11–13	12.1	5 tons	59.4–72.4	69.4	–do–	6–9	7.5	5.2–9.00	7.5
High Pressure Expeller (imported)	–do–	16-20	17.5	Dehulled seed	14.9	14.9	65 tons	85.1	85.1	–do–	2.5–4	3.2	5–85	7.4
Solvent Extraction	–do–	16-20	17.5	Dehulled seed processed cake	16.8	16.8	60 tons	96.0	96.0	–do–	0.5–1.0	0.65	5–8.5	7.4

Table 2. Acreage and production of various oil seed crops.

Year	Average (In '000' Acres)					Production (In '000' acres)				
	Cotton	Rape and Mustard	Groundnut	Sesame	Total	Cotton	Rape and Mustard	Groundnut	Sesame	Total
1947-48	3056	1059	1	65	4181	387	172	(b)	9	568
1948-49	2598	1118	(a)	43	3759	337	185	(b)	6	528
1949-50	2744	907	6	49	3706	433	142	1	6	582
1950-51	3016	1140	1	58	4215	492	196	(b)	8	696
1951-52	3318	1363	1	62	4746	489	197	(b)	7	693
1952-53	3422	1054	1	60	4537	625	125	1	6	757
1953-54	2870	1076	1	67	4014	499	163	1	6	669
1954-55	3136	1275	3	60	4474	544	216	1	6	767
1955-56	3477	1423	4	58	4962	587	218	2	6	813
1956-57	3555	1362	6	61	4984	599	222	3	6	830
1957-58	3590	1347	11	64	5012	598	229	4	6	837
1958-59	3273	1365	9	59	4706	555	262	4	6	827
1959-60	3318	1387	8	76	4789	574	235	5	8	822
1960-61	3195	1233	28	78	4534	593	211	16	7	827
1961-62	3449	1114	27	108	4698	638	202	15	11	866
1962-63	3395	1222	30	74	4721	253	253	14	8	996
1963-64	3634	1173	39	66	4912	824	208	17	8	1057
1964-65	3624	1207	41	83	4955	743	211	20	9	983
1965-66	3858	1091	58	70	5077	816	179	29	7	1031
1966-67	4003	1136	84	75	5298	912	200	46	7	1165
1967-68	4411	1340	125	79	5955	1018	270	73	9	1370
1968-69	4313	1093	86	68	5560	1038	225	52	8	1323
1969-70	4338	1184	105	56	5683	1054	251	61	8	1374
1970-71	4283	1260	75	76	5694	1068	265	44	10	1387
1971-72	4837	1389	102	103	6431	1393	296	56	13	1758
1972-73	4967	1319	77	73	6436	1381	282	44	10	1717
1973-74	4559	1324	94	81	6058	1296	288	53	12	1649
1974-75	5019	1116	100	56	6291	1248	244	56	8	1556
1975-76	4575	1163	107	70	5915	1011	263	60	10	1344
1976-77	4608	1283	111	75	6077	856	287	63	12	1218
1977-78	4555	1019	125	78	5777	574.8	235.1	72.4	12.6	894.9
1978-79	4673	1070	90.	113	5956	473.2	248.2	45.5	18.7	785.6
1979-80	5142	1012	101.	114	6369	728.2	247.1	50.3	19.3	1044.9
1980-81	5210	1030	115.	109	6464	714.5	252.5	57.3	18.3	1042.6

Note: (a) Mean less than 500 acres. (b) Mean less than 500 tons.

Table 3. Oil content and characteristics of plants that offer potential for oil production.

Latin name of plant	Common name	% Oil content	% Fatty acid composition of the oils						
			Saturated			Unsaturated			
			C_{14}	C_{16}	C_{18}	$C_{16:1}$	$C_{18:1}$	$C_{18:2}$	$C_{18:3}$
Asphodelus fistulosus	Piazi	17.5	0.5	5.7	3.6	–	33.1	54.9	–
Carthamus oxvacantha	Pohli	34.8	0.7	5.7	3.6	–	33.1	54.9	–
Argemona mexicana	Satianasi	36.9	–	0.0	6.0	5.8	21.8	48.9	0.6 (recinoleic)
Peganum harmala	Harmal	14.3	–	0.6	0.66	0.67	33.1	58.9	1.1
Salvadora oleoides	Peelo	46.7	52.9	18.9	–	–	5.5	–	–
Momordica charantia	Karela	30.8	–	–	29.5	–	15.8	7.7	46.7
Cucmis momordica	Fut	38.0	23.6	1.2	–	–	16.2	51.7	7.3
Cucmis melo	Sarda	38.4	2.0	3.2	5.4	–	32.9	55.6	–
Cucurbita vulgaria	Watermelon	32.7	–	7.6	6.1	–	35.3	48.7	–
Salvia spinosa	Kanoocha	14.5	10.5	–	–	–	–	89.50	–
pilosum	Tukhm-e-Rehan	16.8	10.32	–	–	–	–	89.68	–
Sesbania aegypties	Jantar	6.0	–	11.2	10.29	–	41.94	31.16	3.84
Nonnorrhops chieana	Mazri	10.0	–	–	–	–	–	–	–
Thuja orientalis	Moorpankhi	5.6	–	5.28	7.3	–	81.3	–	–
Skimmia laureola	Nair	27.0	–	8.3	1.5	2.6	3.4	31.2	32.2
Rosa macrophylla	Gulab	6.0	–	3.8	–	–	25.10	60.10	10.83
Morus alba	Shatut	33.0	–	11.2	1.09	–	3.82	84.06	–
Pruma domestica	Khurmani	42.0	–	2.6	1.1	–	94.7	1.5	–
Grewia asiatica	Falsa	5.0	–	8.3	11.0	–	13.4	64.5	2.8
Citrus aurantium	Sangara	36.0	–	14.2	19.0	–	8.0	54.2	–
Papaver somniferum	Posdt.	45.0	–	11.0	4.2	–	11.4	73.0	–
Bicotiana tabacum	Tambaku	40.0	–	7.6	3.1	–	17.9	79.4	1.0
Vitis virifera	Angoor	15.0	–	5.5	2.4	–	37.0	55.0	–

example of this nature.

The importance of such efforts can be clearly realized in view of the fact that the per acre yield of the conventional oil seed crop is low and large quantity of oil is imported every year (about 450,000 tons for 1982-83) [11]. Increase in the per acre yield of the oil seed crops and the processing of non-conventional oil seeds would add to the vegetable oil resources of the country thus reducing the import bill.

Objective of the Survey

The Pakistan Council of Scientific & Industrial Research, the premier R & D organization of the country, has envince keen interest in the effective utilization of the local raw materials including oils and fats. As a part of its development programme, the Oils, Fats and Waxes Research Division of PCSIR Laboratories, Lahore, initiated a study with a view to establishing the state of the art of oil seed processing technology in the country. The objectives of the study were:

1. Compiling data on the state of the oil seed processing technology with particular reference to performance parameters through a survey.
2. Determining the scope and potential of the existing technology and indicating areas of improvement through modifications and adaptations.

3. Identify the problems and the processing losses of the technology and suggesting solutions for them.

State of the Art

In order to achieve these objectives, survey teams visited all the oil seed processing units, small and large, situated in different parts of the country.

During the course of survey, about 400 processing units inclusive of kohlus, low and high pressure expellers and solvent extraction units were visited for data collection. The data was evaluated and is given alongwith other performance parameters of the units in Table 1.

As a result of the present survey and the previous information, it has been established that the following equipment/techniques are in use for the processing of oil seeds in Pakistan.

i) Kohlu, both wooden and metallic.
ii) Oil expeller (with low and high pressure).
iii) Solvent extraction.

The survey of the state of the art of oil seed processing technology reveals that there are about 10 thousand kohlu units, almost 2500 large expellers and 2000 mini-expellers and 14 solvent-extraction units which handle all the oil-bearing materials for the recovery of oil [12, 13]. The total installed capacity of all these units far exceeds the quantity of the oil seeds available in the country.

There are at present 127 oil mills with a total of 600 expellers in Sind and 426 oil mills with a total of 1835 expellers in the Punjab. Most of these mills are generally old and have locally manufactured expellers. These expellers are comparatively no doubt less expensive but inefficient at the same time. Majority of the mills do not possess delinting and decorticating units for processing cotton seed. As a result, the oil extraction efficiency is low and the cake contains lints and hulls besides 6-9% of oil. The capacity of these mills is about 7500 and 25000 tons per month respectively for the Sind and the Punjab for cotton seed oil expression on the basis of 12-13% oil recovery.

The number of solvent-extraction units, with a total production capacity of 68,000 tons per month of oil is five in Sind and nine in the Punjab. Out of these fourteen units, each unit is equipeed for processing of cotton seed and has a total capacity of 4500 tons of oil per month based on 16% oil extraction from cotton seed.

Problems

The availability of cotton seed to mills is seasonal and the storage of seed is not adequate throughout the country. During the crop season, both the farmer as well as the ginner store their seeds in such a way which result in the heating up the thus deteriorating its quality. Because of these factors, there are substantial oil losses both in quantity as well as quality. In case of over-heated seeds, the extracted oil is so poor in quality that even alkali refining and carbon and activated clay decolourization cannot bleach it to the required specifications. The content of these losses cannot be quantitatively determined as there exist no adequate quality control system at the mills level.

The major stage of oil losses in the processing of oil seed can now be identified as:

i) Low yield of the oil seed crop.
ii) Losses due to inefficient storage facilities.
iii) Processing losses and
iv) Refining losses.

Reasons for losses under (i) to (iii) above have already been described. However, the refining losses can be quantified as the use of alkali has a direct relationship with the amount of free fatty acids (FFA) present in a processed oil. Due to the FFA content of oil, the average refining losses are between 4-7% for rape seed and 9-12% for cotton seed oils, respectively. The refining losses are no doubt losses so far as the quantity of oil is concerned, but if the fatty acids are converted into soap, they fetch a higher price. It has been estimated that one ton of the soap stock will give about 2 tons of laundry soap when processed for marketing purposes.

Scope for Improvements

The state of the art of oil extraction as has been surveyed and described above indicates that possibilities are there for recovering more oil from the presently available sources. The mangnitude of the availability of oil seed cake as obtained from the kohlus and the expellers has been assessed. About 30% of the total production of rape seed is processed at the village level by kohlus and small expellers.

In assuming that all the rape seed produced, 300,000 tons is crushed in the country then about 11,000 tons of oil cake from kohlus and 1,87,000 tons from the expellers, both high and low pressure, with 9.3% and 7.5% of average

residual oil in the oil cake respectively is available in Pakistan. The total available amount of oil in this cake alone works out to be 15,048 tons. Solvent extraction will certainly provide this much amount from rape seed cake alone but efforts can also be made to recover a major part of this oil by improvements in the existing expression technology. In fact, an improved version of the Lahore expeller has already been fabricated and field tested which yielded cake with about 6% residual oil. The design, performance and mechanical improvement of this expeller will form the basis of another paper.

If on the average 1400,000 tons of cotton is harvested in a year in Pakistan then almost 900,000 tons of cotton seed will be produced. At an average of 12% oil recovery from this cotton seed the remainder cake with 6% oil in it, works out to be almost 700,000 tons.

Except for the units equipped with dehulling and delinting facilities, the cotton seed is processed as such for the expression of oil. The residual oil content in the mill expressed seed is variable depending on the type of expeller used. However, 2.5-5.6% residual oil is also available in the cotton seed cake. It has further been estimated that from the decorticated and delinted cotton seed almost 20,000 tons of additional amount of oil could be obtained by the conventional expeller. However, if the delinted and dehulled seeds are solvent-extracted, additional 50,000 tons of oil could be recovered.

The major uses of both cotton seed as well as the rape seed cake is as animal feed. Traditionally the Pakistani farmer is fond of feeding oil-rich cake to the animal and is not aware that de-oiled cake will have proportionately more protein value. It has been observed that with proper quality control, the solvent-extracted meal can not only be converted into better cattle or poultry feeds but also exported for earning foreign exchange.

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