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THE OIL INDUSTRY IN INDIA

By

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PREFACE.

This booklet is placed before the public to awaken their interest in one of India's key industries. Somehow or other, the attitude of the Indian public towards the Seed-Crushing or Oil Industry has been one of despair and hopelessness. The following pages treat the causes that lie at the bottom of such an unproductive attitude, and an attempt is made to point out the remedies which are calculated to ameliorate the present alarming situation of one of our greatest industries. Though not yet recovered from the sad effects of the war, the European Nations are making huge preparations to rehabilitate and reorganise their industries; and it would be a pity, if India were to lag behind on her part.

I shall deem my labour redeemed, if the layman be persuaded to take an interest in this industry, if those who have already launched in it find something useful to know from these pages, if a hope be created in that unfortunate class of seed crushers who have come across nothing but loss and ruin in their trials, and if even a pie be added to the wealth of India by the extension and modernisation of our most promising industry by timely action.

R. M. VAKIL.

KAPADWANJ, 19*th July* 1921.

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THE OIL INDUSTRY IN INDIA.

Part I.

It is universally known that India produces in commercial quantities a greater variety of oil-seeds than any other country. However, the lion's share in the profits arising from making up the seeds is enjoyed by foreign countries, France, England and Germany. Table I is intended to show what a deplorable drain of money is devastating India owing to the most unprofitable flow of exports of Indian oil-seeds as compared with the world's exporting trade.

Table I.*

1913-14.

Name of Seed.	World's exported Surplus.	India's exported Surplus.	Proportion of India's exported surplus to world's exported surplus.
	tons.	tons.	%
Castor Seed ..	137,000	135,000	98
Poppy ,,	25,000	19,000	76
Rape ,, ..	385,000	249,000	65
Groundnut ,, ..	780,000	383,500	45
Sesame ,, ..	264,000	112,000	42
Cotton ,, ..	900,000	284,000	31
Linseed	2,150,000	414,000	20
Copra ..	537,000	38,000	7
Mowra Seed ..	Figures not available.	33,000	100
Niger Seed ..	,,	4,000	100

* From Imperial Institute's, Indian Trade Inquiry Report on Oil-seeds, 1920.

The industrial backwardness of India will be better understood by studying the figures in Table II, where an attempt is made to give a comparative sketch of the cottonseed trade of India and America.

Table II.

1913-14

Article.		India.	America.
Cotton seed			
Produced	tons ..	2,110,000	5,620,000
Exported	,, ..	284,327	7,295
Cottonseed Oil			
Exported	,, ..	10	145,000
Cottonseed Cake			
Exported	,, ..	10,429	357,131

Inspite of India's production of the seed being less than even half of America's the former's exports of the seed are forty times those of the latter; while in case of manufactured products, India's exports of oil and cake are only $\frac{1}{14500}$ and $\frac{1}{35}$ of those of America respectively. It is easy to understand how one of our most valuable raw materials is misused and frittered away.

The causes that maintain this unhappy and unprofitable state of the Indian Seed-crushing Industry are three-fold:—the backwardness of the general public, the apathy of the rich industrial class, and the unsympathetic attitude of the Government.

The importance of attempts to improve the state of agriculture by the use of scientific implements, fertilisers and skilled supervision is recognised on all hands. And yet instances of increase in yield of crops per acre are scarce to be found in India. We are prone to cling tenaciously to the doctrine, " What was good enough for our forefathers should be good enough for us ", and thus to wrap ourselves up in the cloak of time-honoured, non-progressive methods of work. If the farmers were to feed their cattle on carefully prepared compound oil-cakes mixed with other articles of fodder, if the soil were better cultivated by the use of cake fertilisers along with other artificial manures, and if the general public were to pay attention to the numerous advantages of certain vegetable oils hitherto ignored, much economy would be created in the ordinary means of living, a great relief would be secured against famine, and India would make a rapid progress on the path of industrial advancement.

The Commercial Statistics of India show that in 1918 the grand total of large industiral establishments, owned by Government, private individuals and companies, amounted to 4,789, employing 1,292,667 persons—out of which there were only 153 oil mills, employing a meagre total of 8,046 persons. And among these 153 oil mills, those crushing cotton-seed can be counted on one's finger's ends, while in America there are more than 900 mills of this kind. This scarcity of oil mills in India has often been ascribed to the non-enterprising nature of the Indian capitalists who generally invest only in the concerns that have

proved a success, and not in new prospective ones. This remark seems to me off the mark ; for, examples are not wanting that go to prove the disappearance of the shyness and non-enterprising spirit of the Indian capitalist. During the last two or three years hundreds of new concerns have been floated and Indians of all rank have liberally contributed to them. In my opinion, a number of discouraging reports and the losses sometimes sustained by certain oil mills have damped the enterprising spirit of oil-seed crushers. I must point out that these losses were none but invited in so far as sufficient care was not devoted to the erection of scientific machinery, the adoption of scientific methods and proper management. The Imperial Institute's Report too attributes these failres to " the want of technical and commercial knowledge on the part of the management, and failure to recognise the necessity for erecting only the best and most modern machinery and of securing efficient scientific control. " Instead of such scientific and systematic operation of oil mills, we actually meet with mills that are worked in a manner, most inefficient and disorderly, which is sure to drag the concern to loss and ruin.

There are many ways in which the Government can encourage the industry. The whole problem is complicated by tariff questions. The Government can assist a great deal by improving the tariff policy. " The Government can encourage oil industry by preventing the export of the oil seeds, by levying a heavy duty on the seeds exported, by asking the

Railway authorities to reduce the mileage rates for oil seeds and their products. If the Government ask the municipalities to give some concessions to the mills only in their infancy, a sort of bounty in the form of a reduction of taxes, and to maintain the roads to the mills in good state so that the traffic to the mills might not be hampered, the oil industry should receive a further encouragement."

Let us examine several arguments that are advanced against the advisability of establishing seed-crushing mills in India.

Argues the Imperial Institute Bulletin, "India is pre-eminently an agricultural country and there is no reason why it should not, like Java, develop on agricultural lines. The yield per acre of practically every crop grown in India could be increased, and it would be far sounder economically to give attention to the development of agriculture, with a view to increased exports of raw materials than to attempt to start new industries." This statement is simply astounding. Not only does it aid in the campaign of nipping the industrial growth of India in the bud, not only does it persuade the people to avoid paths that would lead to their prosperity, not only does it preach a course that is calculated to render India the unhappy dumping ground for the output of foreign factories, not only does it promulgate a course which greatly increases the economic dependence and helplessness of India, but it ventures to assert a statement, which runs counter to the whole fabric of Historical Fact. It ought not to be forgotten that India, besides being an

agricultural nation, has been the home of Industrial pursuits from times immemorial. It is a matter of common knowledge that the bulk of industries in Europe was imported from India. Take the soap industry. The process of washing clothes in old Europe extended over a period of more than two months, while the Indian process took at most a week. This efficiency of the Indian process came to the knowledge of Holland years ago. This attracted the attention of the Dutch, who, consequently contrived to acquire the art of soap making and washing clothes from India. "The Hindus had a very large hand," says Dr. P. C. Ray, "in the cultivation of the experimental sciences. India has been famous for her metallurgical skill: the wroughtiron pillar close to the Kutub near Delhi, the iron beams in the temple of Puri and Kanarak and the iron pillar at Dhar excite the wonder and admiration of modern experts." Only a few decades ago India supplied some of Europe's most essential wants and luxuries, of which the fine Muslin of Dacca is an outstanding example, and it cost Europe the imposition of numerous heavy duties and perpetration of sinful deeds to crush India's most flourishing industries. These instances have been quoted with a view not of merely singing the glories of India but of drawing the attention of the public to the fact that we have been an industrial nation, that we have fostered families of experts who have turned out productions extracting universal admiration, and that we have nurtured arts and handicrafts in all classes of industrial requirements. We ought

not to be misguided by false attacks, charging us to be a purely or pre-eminently agricultural country but we must open our eyes to the awful waste of wealth that is caused by our weakness in sheltering ideas that lead to our industrial stagnation. To teach a nation " to give attention to the development of agriculture with a view to increased exports of raw materials rather than to attempt to start new industries "—is a good lesson, indeed, so far as the interests of the teacher are concerned!

We shall now consider another statement, which misrepresents the conditions under which the old primitive seed crushing system works, thus advancing an argument against the desirability of establishing oil mills worked by mechanical power. It is said "the country *Ghanis* entail a relatively small initial expenditure and are cheap to run."* The former portion of this statement cannot be denied but the latter is quite unjustifiable. It requires little trouble to inquire into the expenses of working the *Ghani* and the expenses of operating an oil mill by mechanical power. The cost of *Ghani* process is more than three times the cost of milling by machinery. Not only is there a reduction in cost, but there is a decided advantage in the total output. Practically the factory can produce during one day as much as one *Ghani* can produce during one whole year.

Here is advanced another objection. " A large proportion of the oil manufactured at the present

* Indian Munitions Board Industrial Hand-book.

time in India is characterised by its high acid value, which inticates a decomposition of the oil into fatty acids and glycerine due to the non-destruction of enzymatic ferments present in the seed–"* as if the ordinary oils in Europe were far superior ! It requires no effort to see that the oils produced from deteriorated seeds are liable to contain a greater percentage of free fatty acids than those from the fresh seeds. The seeds crushed in Europe have invariably undergone deterioration and decomposition during transit. Hence the oils pressed from these must be necessarily inferior to ours— howsoever uproariously, inferiority of Indian oils may be proclaimed.

On the contrary we have the following recommendation supporting the development of the seed-crushing industry in India. "In any attempts to foster the development of Chemical industries in India, attention should be directed, in the first instance, to industries which make use of the Indian grown raw materials now exported to other countries, where they are worked up into various finished products. Included in these exports are— (1) the raw materials from which important fixed oils and feeding cakes are manufactured."* Inspite of such recommendations very little progress has been made towards the extension of the oil industry in India. The world's demand for all types of soaps, for higher grades of oil suited for culinary purposes, for the production of glycerine on a larger scale, for solid vegetable fats, for lubricants, paints and vanishes, for cattle

* Indian Munitions Board Industrial Hand-book,

food and fertilisers, and last but not the least for butter substitutes, has necessitated the establishment of seed-crushing industry on a larger and more extensive scale. The present output of oil, cake and other products is far short of the demand.

"In Europe and America, the oil-pressing industry has made rapid progress during recent years. Improved yields of oil from the seeds, obtained by the use of more efficient plant either in the form of hydraulic presses or solvent extraction plant, improvements in the quality of the oil, effected both by greater care in decorticating the seed before pressing, by the regulation of temperature during pressing, by improved methods of refinement after pressing, and by careful scientific control of all the processes have been characteristic of this development." We do not see why India too should not proceed on similar lines. In certain most important matters India's position for the seed crushing industry is unrivalled. While Europe is at a disadvantage so far as the seed crushed there is neither fresh nor cheap, India enjoys an enviable position in this matter. Further, India also commands abundance of cheap labour.

The consumption of oils in variou ctures has increased to such an extent th resent supplies fall far short of the demand. (ularly such as are required for edible pur now attracting attention in all the advan ries to a degree scarcely contemplated before th Since the outbreak of war, the world's herds of cattle

have diminished enormously in numbers, and as a consequence the production of butter and ghee has also declined. This has created an enormous increase in the demand for margarine, a very important outlet for certain varieties of fatty vegetable oils. Apart from the margarine industry, these oils constitute the raw product or one of the raw products of several important industries. Thus they are used in the manufacture of paints, varnishes, soaps, candles, linoleum, oilcloth, glycerine, lubricants, greases and a host of other articles. Really, it is a matter of great regret that India suffers an unnaturally huge loss by exportig the very, basic raw material viz. seed, rather than making up the seed within her own boundaries and exporting oils, and even higher finished products. Our seeds go abroad; and in return we receive manufactured products, for which we have to pay prices unheard of . The greatest evil of this state of things lies in the fact that the money we pay for foreign manufactured products reaches back the foreign factory, and there it assists in the extension and modernisation of the industries, with the result that India's dependance is still more aggravated. It is a sacred duty of every Indian and every well-wisher of India to work towards the extinction of the above evil.

Part II.

The average annual production of oil seeds in India is about 5,000,000 tons with an aggregate value of £ 50,000,000 ; while the value of exports, including oils and cakes would be about £18,000,000. The principal buyers of Indian seeds are France, England, Germany and Belgium.

We shall treat below some of the more important oil-seeds viz. Linseed, Cotton-seed, Copra, Groundnut seed, Castorseed and Tilseed.

LINSEED (Linum usitatissimum).

The production of linseed is about half a million tons of which 80 percent and even more is exported.

Table III.

AREA AND YIELD.

	1915-16	1916-17	1917-18	1918-19	1919-20
Area acres	3,333,000	3,564,000	3,797,000	1,989,000	3,101,000
Yield tons.	476,000	526,000	515,000	235,000	433,000

Linseed is most extensively grown in the United Provinces, the Central Provinces, Berar, Bihar and Orissa. It is one of the most important seeds as both the oil and the cake produced from it are in great demand. The chemical composition of the seed is as follows :—

Oil	35—45
Albuminoids	19—23

Carbohydrates	18—24
Woody fibre	7—10
Mineral Matter	3— 5
Water	7— 8

Large amounts of the seed are exported, as will be seen from the following table :—

Table IV.

EXPORTS.

Exports	1915-16	1916-17	1917-18	1918-19	1919-20
Tons	192,987	394,103	140,676	333,516	195,980

Linseed oil belongs to the class of drying oils. The fresh oil is readily saponifiable and is used largely in the manufacture of soft soaps. In hospitals, it is used in making plasters; and technically it is used for making oil colours, varnishes, lacquers, linoleum and oilcloth. Raw linseed oil is converted into the well-known boiled and double boiled linseed oil, which possesses excellent drying and hardening qualities. Uptil very recently linseed oil was considered quite unfit for edible purposes ; but now this oil is refined and is frequently used as a substitute for cottonseed oil.

Linseed cake is consumed in large quantities as a cattle food,and is one of the earliest and most popular

articles of fodder in Europe. Its chief constituents are :—

	Calcutta Cake	Bombay Cake.
Moisture	9.25	9.60
Oil	9.83	10.32
Proteids	33.25	30.83
Digestible Carbohydrates	34.82	33.86
Fibre	5.70	8.22
Ash including sand	7.15	7.17
	100.00	100.00
Sand	2.20	1.92
Food Units	142.	137.

In the case of linseed also, we have been playing in the network of the same unfortunate trade policy which is responsible for the stunting of our industrial growth. Table V compares the trade in Linseed of the two countries, India and America, the figures of which are worth paying our attention to.

Table V.

LINSEED. 1913

	India	America
Production tons.	547,243	453,484
Export tons	413,874	391

TIL SEED (Sesamum Indicum).

This seed is generally grown throughout India except in the United Provinces. The crop is raised most extensively in Bombay, Madras, Burma and Central Provinces.

Table VI.

AREA AND PRODUCTION.

	1915-16	1916-17	1917-18	1918-19	1919-20
Area acres	5,108,000	5,023,000	4,279,000	3,585,000	4,163,000
Yield tons	482,000	513,000	382,200	278,000	480,000

Tilseed is mainly a *kharif* crop, sown from May to July and harvested from October to December. Five qualities of the seed come in the market, white, black, mixed, yellow and red. The white class of sesame has the highest oil-content. The whole seed is frequently used as a foodstuff directly. Large quantities of the seed are exported, because the presence of sesame oil is required in all artificial butters by law in some European countries. Sesame is found to contain :—

Oil	..50—55
Albuminoids ..	..20—22
Gum	.. 7— 8
Mineral Matter ..	.. 6— 8
Water	.. 4— 5

Sesame oil is intrinsically one of the best oils for the manufacture of margarine, and is the most predominant substitute for olive oil. There will always be a considerable inducement to margarine makers to use it. In India the oil is considered to be of a very high grade for cooking purposes. The country *ghanis* crush tilseed in almost every Indian town and supply the local demand. It has been a frequent practice with some of the *ghani* owners to adulterate tilseed oil with groundnut oil.

Sesame oil is yellow and agreeably flavoured. It does not easily become rancid and dries very slightly. The constants of sesame oil are as follows :—

Specific gravity at 15° C ..	0.923 to 0.926
Refractive Index at 15° C ..	1.4748 to 1.4762
Solidifying-point	—4° to—6° C.
Saponification Value ..	188 to 193
Iodine Value	103 to 115

The tilseed cake has a good market in Ceylon, where it is used chiefly for manurial purposes. In India, it is in general demand as a valuable cattle food either alone or in conjunction with *poonac*.

The constituents of the cake are ;—

	Burmese	English
Moisture	7.20	9.3
Fat	17.80	11.9
Albuminoids	35.88	44.5
Carbohydrates	22.44	20.9
Fibre	4.43	4.5
Ash	12.25	8.9

COCOANUT (cocos nucifera.)

Cocoanut grows in a most flourishing state in the Malabar districts, Cochin, Canara and Ratnagiri districts.

The seed kernels, which before their development consist almost exclusively of a sweet, liquid, milky albumen—cocoanut milk—contain a hard, fleshy, white oleaginous albumen—copra—with a nutty flavour, and enclosing a little milky sap in a central cavity. This fleshy substance in its undried condition contains about half its weight of water; and when dried, has an oil-content of 60-70 percent. Manilla copra yields 59, % Ceylon copra 65 % and Malabar copra 68 % of fat.

The cocoanut has made important contributions to commerce in giving copra, oil, cake and coir. These, however, do not exhaust "the products of the tree, every part of which has its own definite use or uses. The leaves are used for hutting and roofing, and for he manufacture of brooms, baskets, and umbrellas, and are burnt for manure. The shells are the fuel of the coast. The juice is drunk either fermented or unfermented, and is made into jaggery and distilled into arrack. The nuts are eaten, the oil is used for lighting and in cooking; the trunks are employed in building or are used as water pipes."* Over and above all these, there has been produced charcoal from the shells, which has high gas-absorbing properties.

*Indian Munitions Board Hand-book.

Cocoanut oil is an oil in summer, and a fat in winter. Its metting point is 23° to 26° C. It has a pleasant odour and a sweet taste. The oil from Malabar is the finest cocoanut oil in the world. It is colourless; and when refined, presents itself as a strong rival of ghee. There are now on the market large quantities of vegetable butters made by treating cocoanut oil with alcohol and bone black, these being entirely free from odour, taste, and acidity.

The analytical figures for the oil are :—

Specific Gravity	0.9259
Refractive Index	1.441
Solidifying point	14° to 23°C
Melting-point	23° to 26°C
Saponification Value	225—268
Iodine Value	8—9
Reichert Meissl Value	6—8

The high saponification value and Reichert value of the oil are due to the presence of a large percentage of laurin, myristin, caprin, caprylin, and caproin. The cocoanut oil is one of the best oils for the manufacture of hard soap.

Cocoanut cake or Poonac is an important cattle food. It contains :—

	Bombay Cake.
Moisture	11.90
Oil	11.83
Albuminoids	23.12
Carbohydrates	35.70
Fibre	7.90
Ash	9.55

CASTOR SEED (Ricinus Communis.)

The plant is extensively grown over India as a mixed crop. A fair average yield of the Castor is 300 to 400 lbs. per acre. The crop takes 8 to 12 months to mature.

Two principal varieties of the seed come in the market. The large-seeded variety yields the oil, which, before the coming of kerosene and electric light, was in great demand as an illuminant. The small seed gives the well-known medical oil.

We have seen in Table I. that India's exported surplus of the seed in 1913-14 was 98 % of the world's exported surplus. India is the main source of the world's supply of castor seed.

The oil, which forms about 40 % of the seed, is of the non-drying class, and is of great value as a lubricant. It is extensively used in the manufacture of transparent soaps, preserving leather, adhesive gums, and the Turkey Red oil for alizarine dyeing. However, its very recent use in the lubrication of aero-engines has increased its importance to a great extent. Its medicinal use depends upon the fact that it contains an alkaloid.

The Castor cake is unsuitable for cattle feeding owing to the presence in it of the poison, ricinin. But it is an excellent fertiliser and is greatly consumed both in India and abroad. It is specially used on sugarcane fields. Below are given an analysis of castor cakes produced by different milling processes.

	Cake made from Whole seed.	Decorticated seed.	Cake meal by solvent.
Moisture	9.85	10.38	11.75
Ash	15.02	10.50	6.05
Oil	5.25	8.75	1.10
Proteins	20.44	46.37	30.62
Fibre & Carbohydrates	49.44	24.00	36.52 + 13.96
Phosphoric Acid ..	1.62	2.26	

GROUNDNUT (Arachis hypogaea.)

The groundnut crop is sown from May to August, and is harvested from November to January.

Table VII.

AREA AND PRODUCTION.

	1915-16	1916-17	1917-18	1918-19	1919-20
Area acres ..	1,664,000	2,334,000	1,936,000	1,107,000	1,555,000
Yield tons ..	1,058,000	1,196,000	1,056,000	626,000	800,000

It is chiefly grown in Madras, Bombay and Burma.

Table VIII.

PRODUCTION (TONS) OF GROUNDNUT IN EACH PROVINCE.

Province	1915-16	1916-17	1917-18	1918-19	1919-20
Madras ..	633,000	825,000	680,000	442,000	569,000
Bombay ..	309,000	260,000	272,000	85,000	129,000
Burma	116,000	111,000	104,000	99,000	102,000
Total ..	1,058,000	1,196,000	1,056000	626,000	800,000

The seed, besides being used as an oil-yielding article, is extensively employed as a food stuff. The shelled nuts are roasted, salted and brought in the market as a very popular food-stuff.

Large quantities of the seed are exported from Madras to Europe, Marseilles being the best market for it. The bulk of the groundnut shipped from India are of a low grade. This is due to the fact that the method of shelling is an old primitive one involving the operation of the wetting of the seed, thus rendering the seed liable to suffer chemical decomposition. Such damaged seed yields an oil of a very low quality and of no use in edible purposes. The remedy of such an undesirable situation is to be sought in the dismissal of the old shelling process and the adoption of shelling by machinery. The low quality of the present seed going to Europe is a serious obstacle in the way of successful milling ; hence

earnest efforts are made by the foreign importing countries to improve the quality of the seed received by them. The Imperial Institute Bulletin remarks "It is of vital importance that steps should be taken by the Government of India to encourage in every possible way the extension of the process of shelling by means of machinery."

The British manufacturers have now seriously directed their energies to margarine, and groundnut oil is a valuable raw article therein. Hence the foreign demand for groundnut and groundnut oil will be increasing rapidly. In these circumstances, the Government of India can benefit us to a great extent by adopting a policy, which favours the export of the groundnut oil and suppresses that of the pure seed.

In America, the groundnut has captivated the whole public by supplying Peanut Margarine and Peanut Butter. This industry has advanced widely there. Some of the manufacturers announce that Peanut Margarine has better properties, from the physiological point of view, than natural butter. This subject is daily growing in importance, and the attention of the best and greatest scientific experts is turned towards the utilisation of groundnut oil for higher edible products. When we compare these American activities with India's Brobdingnagian exports of seeds, we simply stand aghast.

The press groundnut cake is a valuable cattle food. However very recently experiments made by

Mr. Mackenzie Wallis have shown that it can with advantage be used for mixing with wheat flour for human consumption. The cake has given us Nutramine which has met with great success in the manufacture of biscuits. We may at this place mention that a similar, but more extensive, employment of cotton seed flour has come in popularity in the United States.

In Burma some of the biggest oil mills crush the seed without shelling, and I have found the cakes from this to contain :—

	Undecorticated Burmese Cake.		
Moisture	7.33	6.95	8.30
Oil	8.20	8.54	9.25
Proteids	28.13	27.58	29.25
Carbohydrates ..	24.50	24.68	21.94
Fibre	27.30	27.88	26.53
Mineral Matter ..	4.54	4.37	4.73

The country ghanis press the seed half decorticated, and I obtained the following results on the analysis of a sample of such cake :—

Moisture	7.27
Oil	12.68
Albuminoids	47.54
Carbohydrates	16.72
Fibre	10.00
Ash	5.79

COTTONSEED (Gossypium herbaceum).

Indias' production of Cottoseed is next to that of America only, as will be seen from the following table:—

Table. IX.

AREA (ACRES).

Country.	1916	1917	1918	1919
United States.. ..	35,224,000	33,827,000	35,993,000	33,534,000
India	17,746,000	21,745,000	25,299,000	20,997,000
Egypt	1,718,000	1,740,000	1,365,000	1,633,000
Japan	5,000	7,000	7,000	6,000

Cottonseed is one of the most important raw materials, in which a host of other industries has its orgin. In the United States of America this seed has been worked up so very profitably and in such a variety of industries that a complete treatment of the Cottonseed Industry would itself require a number of volumes to be written. There is not a single product or bye-product in the Cottonseed Industry which is not turned to useful and profitable account.

The seed-crushing authorities generally divide cottonseed into two distinct classes, viz. the white seed, and the black seed. The American and Indian plants yield seeds of the former class, while the Egyptian yields the latter. The distinguishing

feature of the two is that from the Egyptian seed the fibre is removed completely in the gin ; on the other hand, the American and Indian seeds leave the gin with a considerable amount of the fibre still adhering to their husks. On this account, the black seed is termed also naked or bald ; and the white seed is known as fuzzy, fluffy seed.

The history of the developmentof the Cotton-seed Industry affords an extremley interesting topic, but our aim in this booklet being to awaken the public mind in the matter generally, and to show the immensity of the economic loss that menaces India owing to the non-development of one of her key industries, we shall keep it for some future day to submit to the public a detailed history of this Industry.

The Indian seed might be taken as having an oil-content of 19%, while the American seed 24%. On an average, the following might be taken as being the constituents of Indian and Burma cotton seed :—

	Indian Seed.	Burmese Seed.
Oil	..18—19%	14—15%
Cake	..34—35%	30—31%
Husk	..45—46%	54—55%
Sand	.. 1—2 %	1—2%

A sample of Burmese Cottonseed, on being analysed by me, gave the following contents :—

Moisture	8.68
Oil	14.65

Albuminoids	19.36
Carbohydrates	28.52
Fibre	23.34
Ash	5.45

The Burmese Cottonseed has a very low oil-content ; on the other hand, there are certain varieties of Indian seed, such as from Central Provinces, which contain oil to the extent of even 23 %, reaching very nearly the American level.

There are rwo processes of milling Cottonseed, viz. the English and the American. The former crushes the whole seed, while the latter separates the kernels from the husks and crushes only the kernels. The superiority of the American practice is proved beyond question, though there are attempts from certain British quarters to uphold the method, which has been practised for a long time in England. The root of the whole problem is in the fact that England designed methods of milling seeds at a time, when she was more in need of the cake than of the oil. This led to the adoption of the non-decortication system in England. However, very recently the immense benefits of the decorticating process have come to be recognised on all hands ; and British seed-crushers are directing their energies in establishing the American practice in the United Kingdom. The advantages of the American system are, that the husks, as separated, can be very profitably utilised to yield cotton-fibre and shell-bran, that the resulting cake is bright, of superior feeding value and less

liable to rot, and lastly, the oil produced is of a much better quality in points of colour as well as chemical properties, thus entailing less loss on being refined.

The husks, from which the kernels are removed in the decorticating operation, have a fair amount of fibre adhering to their surface. This fibre was not formerly, and is not even now at most places, separated from the shell-bran, being thus forced to uses most unscientific and unprofitable. However, "of recent years means have been devised for the mechanical separation of the hulls into their component parts of cotton fibre and shell-bran, the former being employed for the manufacture of explosives, paper, artificial silk, cellulose acetate and other cellulose derivatives, and the latter as a basis for the production of various forms of mixed feeds for cattle."*

Cottonseed cake has been used in large quantities for feeding cattle. Below are given a few analyses of different varieties of cottonseed cake.

UNDECORTICATED CAKE.

	English	Bombay	Egyptian	Burmese
Moisture	13.75	11.6	12.3	7.80
Oil ..	6.56	4.6	5.1	5.06
Albuminoids	24.62	19.4	22.9	20.49
Carbohydrates	29.28	38.0	33.7	40.12
Fibre ..	21.19	20.1	20.7	22.06
Ash ..	4.60	6.3	5.3	4.47

* Ed. C. de Segundo.

SEMI-DECORTICATED CAKE.

Moisture	12.10
Oil	6.80
Albuminoids	26.56
Carbohydrates	28.69
Fibre	20.75
Ash	5.10

DECORTICATED CAKE.

	Indian	Burmese
Moisture	9. 00	8.40
Oil	10.00	8.80
Albuminoids	45.50	35.75
Carbohydrates	23.00	30.82
Fibre	5.50	9.13
Ash	7.00	7.10

It will be seen from the above figures of analysis that Cottonseed cake is considerably rich in Proteids. This fact and a few other physiological considerations have brought about a great movement in America, which is popularising the use of cottonseed cake powder as a diluent for wheat flour. We have seen in the case of groundnut cake that it has been possible to use it for human consumption. Similar is the case with cottonseed meal or we may better say, cottonseed flour. This flour is known in the United State as "Allison flour" in honour of its originator. The American public is not only ready for cottonseed flour, but the demand is far ahead of the supply, and is increasing rapidly. This flour is "twenty-five

times as nutritious as potatoes, five times as nutritious as corn meal, and four times as nutritious as oat meal."* The constituents of cottonseed flour are:—

Protein	..51—52
Fat	..11—12
Nitrogen-free extract ..	..22—23
Fibre	.. 3— 4
Water	.. 7— 8
Ash	.. 6— 7

The nitrogen-free extract of cottonseed flour is composed most largely of a sugar, known as raffinose, and contains no starch. On the contrary whear flour has a high percentage of starch, about 2 % of fat and 10 to 11 % of protein. Thus to obtain a balanced food, the best course would be to use cottonseed flour as a diluent for wheat flour, which has a low percentage of protein and a high percentage of starch. Experiment and experience recommend to use a mixture having three parts of wheat flour and one part of cottonseed flour.

The introduction of cottonseed flour in the field of foodstuffs for human consumption has brought with it immense economy in the maintenance of livelihood. Many Biscuit firms and bakeries are using tons and tons of this flour in America. In these days of anxious food situation and "high prices," the economical or wasteful use of such important foodstuffs may make the difference between efficient living or expensive, insupportable living.

* Cottonseed Crushers' Association at Dallas, Texas. 1917.

The Cottonseed Oil, as directly received from the press is crude and unsuitable for human consumption, as well as industrial purposes. It has a black reddish colour, and contains a lot of objectionable impurities. This necessitates the refining of the crude oil. Mechanical, suspended matter is removed by filter-pressing. The chemical impurities chiefly contain colouring matter, free fatty acids and free glycerine. The refining process involves the removal of all the above impurities. Part of the mucilage is removed in the process of filter pressing.

The art of refining lies in the most economical removal of colouring matter and free, fatty acids from the crude, black oil. The earliest refiners simply confined their attention to the removal of colour ; but most important developments have taken place in the refining processes ; and now the cottonseed oil is brought to market in such a highly purified and refined state as to be absolutely colourless, odourless and tasteless.

The refining process might be said to be conducted in three stages, viz.

(1) Removal of free fatty acids and part of the impurities.

(2) Decolourisation of the oil.

(3) De-odourisation of the oil.

In the first stage the crude oil is mixed with a caustic soda solution, whose quantity and strength are determined in the Laboratory after an extremely

careful analysis and testing of the crude oil. The oil is then washed, cleaned, steam-dressed, and made ready for the second stage. Here, the oil is bleached by being treated with fullers' earth, or floridin or any suitable bleaching material, and then filter-pressed. In the last operation, the oil which comes in a neutralised, decolourised state, is subjected to the action of superheated steam under vacuum, in the course of which all objectionable vapours are distilled off. The oil, after passing through all the above stages, comes out in a pure, neutral, colourless, odourless state, being fit for use in the manufacture of artificial butter substitutes and other industrial purposes.

Probably, however, the most interesting process of recent date is that known as the Oil Hardening Process, which enables most liquid oils to be turned into solid fats almost indistinguishable from tallow. We reserve the treatment of this process for the next section.

We shall close this part of our subject here, and shall consider in the coming section a few problems relating to seed-crushing machinery, and other technical sides of the industry.

Part III.

The seed, after being purchased, has often to be stocked according as commercial considerations require. It is a characteristic of every Indian Oil Mill never to pay due attention to the method of storing the seed. The injury rendered by such careless storing of the seed is of no small importance. The most advanced Oil Mills abroad keep storage rooms, built upon scientific principles. These rooms or godowns are dry, airy, and equipped with mechanical appliances for the frequent movement of the seed from one spot to another. Moisture is a deadly enemy of oil-seeds. This moisture, whether existing within the seed itself or attacking it from outside tells upon the chemical constitution of the seed to a great extent. It softens the husks, promotes the chemical decomposition of the seed-kernel, and favours the growth and consequent ravages of fungi, mould and other injurious germs. The remarks that we have previously made about the deteriorated condition of the seeds reaching Europe will be now thoroughly understood by the reader who will take pains to imagine the length of the period during which the seed travels in a moist atmosphere. The labour and expenses incurred in systematic storage of the seed are sure to be repaid in the form of decidedly superior results both in the quantity and quality of the oil and cake produced.

The process of milling the seed involves broadly the following operations :—

(1) Cleaning,
(2) Decortication,

(3) Roll-grinding,
(4) Cooking,
(5) Moulding,
(6) Pressing.
(7) Paring.
(8) Recovery of oil from very oily parings.

(1). CLEANING.

The seed-cleaning operation is necessary both for the good of the machinery as well as the seed-products. The seeds as reaching the mill often contain a good deal of impurities, such as dirt, sand, pieces of stone, iron etc. If these impurities are not removed, the wear and tear of the machinery is increased, and sometimes even accidents may follow owing to the obstacles obtruding the free movement of various mechanical parts. The decorticating machine or the rollers which come in contact with such impurities get their huller-plates broken, or the surfaces bruished or pedestals outcentred.

Moreover, the presence of impurities adds to the percentage of sand and non-nutritious stuff in the cake, thus lowering its value, and casting a slur upon the credit of the crusher.

The best plants for cleaning oil seeds are made by American Manufacturers, who have brought the efficiency of these machines to a very high standard. All the dirt, sand, stone and extraneous matter is removed by these machines, the heavier impurities

being removed by means of screening and winnowing contrivance, and the lighter ones by a blower, the draught of which carries them away. Magnets are used to remove iron pieces.

(2) DECORTICATING.

We have previously referred to the process of decortication, which is an American practice, as opposite to the English practice. This system is of a very recent origin. The decorticating machine, or the " Huller " as it is technically termed, grinds the seed in such a way that the kernel and the husk are separated. The mixture of husks and kernels falls upon a sieve, by means of which the kernels are sieved down from the husks, and are carried to the rolls. The husks have a fair amount of kernel powder attaching to their lint; hence to recover these kernels, the husks are passed through a hull beater, in which they are beaten, and the kernels separated.

The process of decortication has been extremely beneficial to the seed crusher. At some places it has been carried to such a nicety that whole , unbroken kernels are efficiently taken out of the seed. Both the oil as well as the cake from decorticated seed are far superior in quality to those from the undecorticated seed.

The American manufacturers hold a prominent place in making decorticating machines.

(3). ROLL-GRINDING.

The seed, after being cleaned and decorticated, passes through the rolls. The rolling operation requires considerable skill, as each kind of seed needs somewhat different treatment. The oil-cell of the seed is fractured, and the mass rendered fit for being treated in the hydraulic press. It should be borne in mind that no seed should come out either whole or partially crushed, as the presence of such seed is a source of great loss.

(4). COOKING.

The most important and delicate portion of the milling processes is the cooking operation. This is performed by heating the roll-crushed seed in a kettle, which has an outer jacket for containing steam, and a mechanical stirrer inside for mixing the mass uniformly. There are numerous advantages accruing from the proper heating of the seed. The oil cells, which have been already bruised in the rolls, further expand, and consequently render the flow of of the oil easier. Also any albuminous matter present in the seed gets coagulated, and hence, when being treated in the hydraulic press, is retained in the cake, where its presence is of great benefit and value.

Different seeds, nay, different samples of the same seed require different cooking conditions. It is a matter of great regret that in Indian Oil Mills, little, if any, attention is paid to the heating of the seed ; consequently the seed has to suffer all the evils

of under-cooking and over-cooking. Carelessness in this important process leads to the corruption of both the oil and the cake in quality.

If good results are desired, the first and foremost care of the seed-crusher ought to be the proper regulation of the cooking operation.

(5). MOULDING.

A suitable amount of the heated mass is wrapped in bagging cloth and given the shape of the cake by the moulding machine, thus rendering it fit for being placed between the plates of the hydraulic press.

(6). PRESSING.

The moulded cake is carefully placed in exact position between the press plates. The material is then compressed, and the oil is extracted. The pressure usually applied is 1½ to 2 tons per square inch. Some seeds require double pressing. For such seeds rich in oil, the best arrangement is to use the Cage Press for first pressing, and the Anglo-American Plate Press for second pressing.

(7). PARING.

The cake as coming out of the press has its edges very oily, sometimes this oil content rising to 30—40%. These oily edges are cut off by the paring machine. The cake is thereby given a symmetrical appearance. The parings are re-ground by edge-stones and again pressed.

(8). OIL RECOVERY.

In the hydraulic press, owing to compression, lumps of meats full of oil come out of the open sides of the bag. Some of the oil mills take out these oily lumps, and directly mix with the heated mass in the kettle. This is a most unscientific procedure, resulting in the fresh lot of meats in the kettle being vitiated. The best method is to extract all oil from it by means of a centrifugal machine, and then to send the residue to the kettle.

An oil mill, to be successful, must be furnished with the above machines; and though an extra amount of power and expenses is necessary, the benefits derived therefrom are proportionately far greater.

CHEMICAL EXTRACTION OF OILS.

Thus far we have treated only the pressing of the seed by mechanical contrivance ; but very recently the process of extracting the oil from seeds by means of chemical solvents has come into existence. The preliminary treatment of the seed is the same as in hydraulic mills, but the crushed material, instead of being sent to presses, is transferred to extractors. Here it is acted upon by chemical solvents, the ordinary forms of which are Benzene, Carbon Tetrachloride, Carbon Bisulphide and Petroleum Ether. These solvents extract out the oil to an extent of 98-99% of the total oil content. The solution is heated ; the solvent evaporates, re-condenses and is used back ; while the oil only is left behind.

The greatest drawback of this process was that both the oil and the meal retained traces of the solvent and were consequently unsuitable for edible purposes. Now this difficulty is overcome by improvements in the manufacture and purity of the solvent, and also in refining processes.

Chemical extraction is particularly applicable to seeds, the oil and cake from which are used, not for edible but for technical purposes; for there is a distinct gain in the larger yield of oil and also the freedom of the meal from oil. The fat-free meal is of superior quality as a manure. In England the bulk of castor seed is treated by the extraction process.

HYDROGENATION OF OILS.

Hydrogenation of oils is one of the most interesting processes of recent date. It converts the liquid oils into solid fats through the medium of hydrogen, assisted by catalysts. Almost all liquid oils contain a large proportion of unsaturated fatty acids, which when supplied with the extra atoms of Hydrogen required for saturation, are transformed into fats of the consistency of stearin and tallow. The operation is conducted by passing hydrogen at pressure through the oil in the presence of a suitable catalyst, the necessary conditions of temperature, pressure and time being carefully maintained.

We cannot over-estimate the bright future in store for the Oil-Hardening industry. All advanced countries have these plants, and are annually

producing enormous quantities of hydrogenated or hardened oils. For the purposes of modern industries, the world's supply of natural fats is deficient; the Hydrogenation process permits us to make good this deficiency. Unexpected uses for hardened oils have been and continue to be discovered; hence the market for these oils is constantly broadening.

Oils, when hardened, have a wide commercial applicability. They are utilised in manufacture of Candles. Soaps and Sizing compounds; however, the greatest headway in the application of hardened oils, specially Cottonseed and Ground-nut oils, has been in the field of edible products.

In Cotton Spinning and Weaving mills, tallow is used in large amounts for sizing. Some of these mills purchase tallow, that is already refined; while others buy crude tallow and refine it in their own factories. Any how, the product has the drawback of being expensive, and the mill owners hunt after a thing, which would serve the purpose of tallow more cheaply. The hardened oils afford an excellent substitute here, which is not only cheaper but superior also.

The hydrogenated oils find a wide use in the Soap industry. It is not exaggeration to say that in near future, the raw material for soap will principally consist of hardened oils, rather than liquid oils, or tallow and vegetable fats. Cocoanut Oil, Palm Oil and Tallow which are at present the most widely used raw materials for soap, have become very costly;

because they are in great demand for manufacture of higher articles. Hence, the hardened oils will have an easy entrance into the Soap industry. The soap from hardened oils has the same consistency and other properties as that made from tallow and vegetable fats, the recovery of the valuable product, glycerine, being not interfered with at the same time.

The best and widest application of hardened oils is in the manufacture of edible foodstuffs. By the process of hydrogenation, wholesome edible fats of the consistency of Butter and Lard are now produced entirely from hardened Cottonseed Oil. Hydrogenation not only converts Cottonseed oil from the cheaper liquid into the higher priced solid form, but also changes its taste, colour and odour. Colour altogether disappears, and the oil gets white. Odour is abolished; and taste, and quality are improved, for traces of certain unsaturated bodies thought to be slightly toxic in nature are destroyed during the process.

In our opinion, the introduction of hardened Cottonseed, Groundnut and similar vegetable oils would be a boon to the masses of India. Ghee has gone very high in price, so much so that Indian peoples of the poor classes are altogether unable to spend after this expensive fat, though it is one of the most important items in the foodstuffs consumed by Indians. Would it not be a source of economy as well as relief, if a ghee substitute were prepared from hardened oils? To-day, in all parts of India, adulteration of Ghee by various sorts of fats, oils, flours and

tallow is flagrantly practised ; and yet, the Indians have to use the adulterrted product owing to sheer necessity. If hardened oils could be prepared to serve the purpose of Ghee either alone or as mixed with Ghee, there would result great economy for the poor masses. Investigations made in this direction by methodical researches are apt to yield fruitful results.

CONCLUSION.

We have seen, in the pages behind, some of the most salient features of the seed-crushing industry in India. The most predominating impression upon our mind is that India has in the past neglected totally the development of one of her greatest industries, and even to-day, in the vortex of political excitement and industrial deadlock, this industry is not receiving the proper attention of the Indian people. The few figures given previously to show the comparative production and export of seeds by India and America sadly point out to us how one of our key industries is allowed to rot owing to want of care, knowledge and state aid.

The destiny of a nation in visible future will be determined by its economic and industrial advancement. Though crippled by the world war, all the European nations are making huge preparations to revive their industries and expand them. Germany is frantically labouring to rehabilitate her commerce and industry; England is designing great schemes to extend her trade: nay, some of these European nations rely for the execution of their schemes upon the strength of India's production and supply of the raw material. It is a pity that India allows her virgin treasures to be raped by foreigners, her own people standing as spectators, and often even stimulating the alien raider.

If we want to extricate ourselves from the grip of poverty and dependance, the first thing for us

to do is to dismiss root and branch all idea of our unfitness and of the unsuitability of circumstances for industrial progress. What an enormous loss is suffered by India owing to the exports of oil seeds! The average annual exports of India's seeds amount to 800,000 tons, valued at Rs. 180,000,000 nearly The profits arising from crushing the above quantity of seeds would be Rs. 36,000,000, if not more. Not only is this huge profit lost to us, but we further suffer economically as the products from these seeds are employed in the manufacture of soap and a thousand other articles, for which we have to pay ruinous prices.

I have shown previously how attempts are made by interested parties, abroad as well as in India, to impress upon us the economic unsoundness and inadvisability of extending our seed crushing industry. The hollowness of such arguments has been exposed in the first part on pp. 5-8. We should not be shaken in our onward progress by such intentionally untrue reports. One fact goes farthest to damp our spirit in the matter: it is the unsuccessful working of many Indian Oil Mills. However, we are in fear of falling victims to superstitious and non-progressive beliefs, if we permanently cling to these. The reasons for the unprofitable operation of oil mills have been given previously on p. 4. If proper care is devoted to the operation of oil mills on sound, scientific principles, erecting only the best machinery and carrying on all work under efficient, systematic control, success is sure. We must bury the by-gone blunders in the past, and build more cautiously, and not less energeti-

cally on the experience of the same. National mistakes are but stepping stones to the true path. Mistakes come not for daunting, but for guiding and leading us to the correct goal. Below is given a sketch of some of Englands' ridiculous mistakes.

"I assert without fear of just contradiction that if the British public thoroughly understood some of the straits to which we are put in the war, they would never again consent to the lack of control of investment which has obtained in the past. I have referred to the case of Zinc—a case, which simply means that before the war the capital which went abroad ought to have remained at home to give us a Zinc industry, commensurate with our great requirements. With the bad case of Dyes the public is only too unhappily familiar. With the aid of the Government a big dye company has been built up to remedy the neglect of capital to invest in this trade. Let me give another instance. Most people know that the greater part of our butter comes from abroad. In late years, owing to the work done by German Chemists, it has been found possible to utilise nearly every known vegetable oil to make the butter substitute known as margarine. We are an industrial nation, and yet we were content for the margarine industry to be chiefly developed on the continent of Europe. Germany made her own margarine, but we draw most of ours from Holland. So it falls out that in the middle of a terrible war, for lack of oil producing plant and for lack of margarine factories, we find ourselves compelled to send the oil materials of our Empire to Holland

on guarantee that the Dutch send the material back to us as margarine. Was ever such a comedy played in the industrial affairs of the country, which Napolean so mistakenly called a 'nation of shop-keepers'? Does any one imagine for a single moment that if the resources of the British Empire had belonged to Germany she would have allowed herself to be in such a position in time of war."*

The above criticism has been quoted not to arouse any sense of ridicule for England but to show how this same England is to-day making Herculean efforts to remedy the past evils with the aid of her statecraft and science. Germany also is engineering all her schemes with an unparalled scientific ferocity.

For success, there should be a combined move and a co-ordination of efforts on the part of the Government, the transport companies, the port authorities, the Banks, the merchants, the brokers and the oil-seed crushers. The German oil seed crusher has the advantage in being able to enlist the assistance of trading and industrial Banks, which provide capital on long credits for equipment, and extension or modernisation of works. We have to take these instances to heart, and conduct our industrial campaign on sound, scientific principles,—forgetting all pettifogging in a world which is learning to deal with things on a world scale; not being daunted by false, discouraging reports, though a hell of these be pouring in. Keeping science and commercial integrity as our

* British Dominions Year Book, 1916.

watch-words, let us make our onward progress in the industrial march of the world, remembering the impassioned words of one of India's greatest sons, Dr. P. C. Ray :--

"If I could for a moment command the organ voice of Milton, I would exclaim that we are of a Nation not slow and dull, but of a quick, ingenious and piercing spirit, acute to invent, subtle and sinewy to discourse, not beneath the reach of any point the highest the human capacity can soar to."