SURVEY AND UTILISATION OF AGRICULTURAL AND INDUSTRIAL BY-PRODUCTS AND WASTES

COMMITTEE ON NATURAL RESOURCES
PLANNING COMMISSION
GOVERNMENT OF INDIA

FOREWORD

Utilisation of wastes of agriculture and forestry and of by-products of industry has received considerable attention in the industrial countries of the West in recent decades. Through appropriate measures for utilisation of these materials, it has been possible to conserve valuable natural resources, reduce costs of production, and also in many cases to solve problems of public health and welfare created by indiscriminate 'dumping' of waste materials or discharging of industrial effluents in rivers and lakes. In India, the subject has not received much attention so far and large quantities of waste materials and by-products are allowed to go unutilised.

This series of studies on utilisation of agricultural and industrial wastes is an attempt to survey the field, and in particular to identify the areas in which measures for utilisation can lead to appreciable improvements in resource utilisation and saving of materials. The series relates to fifteen subjects in the fields of agriculture, animal husbandry and fisheries and manufacturing industries. The studies have been done with the assistance of the concerned specialised agencies of the Government. I hope these studies will help to draw the attention of Government, organised industry, and the general public to this important problem which will grow in magnitude as industrial development proceeds and that recommendations will receive the attention they deserve, and that appropriate programmes of utilisation of wastes will be incorporated in our successive Five Year Plans.

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August 7, 1963

PREFACE

The Committee on Natural Resources at its meeting held on 24th December, 1961, approved a study on utilisation of wastes and by-products of agriculture including forestry, animal husbandry, fishery and industrial wastes. The Committee felt that there were large quantities of such wastes which were at present used in an uneconomic manner or left completely unuitlised, *e.g.* husk, straw, corn cobs, non-edible vegetable oilseeds, inferior fibres, nutshells, feathers and bones, sea-weeds, etc. In some of the advanced countries of the world these wastes are usefully exploited and add to the national wealth. Modern advances in science and technology have led to very profitable utilisation of such products, and there is scope for this work in India too.

A Working Group, consisting of representatives of the Ministries of Food and Agriculture, Economic and Defence Coordination, Steel and Heavy Industries, Mines and Fuel, Council of Scientific and Industrial Research and the Planning Commission was constituted. The Working Group was directed to survey the location and availability of waste products, to make a list of various uses to which they may be put in the light of experience of other countries and known technological possibilities and to work out the economics of such utilisation. Where the utilisation was economically feasible, it was to be indicated; where there was need for further research for effective utilisation of wastes, the Group was asked to make recommendations to that effect. In a number of cases information about quantities of waste products is not available and surveys are required.

The Working Group met on 26th March and 28th August, 1962. The basic papers which were prepared by the various institutes and organisations as well as individual experts were revised. The Planning Commission at their meetings held on 2nd May, 27th and 29th June, 1963, approved the studies.

The studies have indicated that most of the waste materials are potential sources of raw materials for various industries. For instance, it has been established that blast furnace slag can be profitably used for the manufacture of cement; protein rich food can be made from sea-weeds; by-products of coal carbonisation can be used in the manufacture of toluene and other organic compounds which are vitally needed by the defence industries; utilisation of minor non-edible oilseeds like *mahua, neem, karanj, undi,* etc. would go a long way in reducing the rising pressure of demand on other edible oilseeds which are now being used in the soap and cosmetics industry. Full details of the products that can be obtained from various wastes and by-products have been dealt with under each item.

Some of the obstacles in the way of economic exploitation of these wastes and by-products are non-availability of technical guidance to the prospective entrepreneurs, lack of a ready market, and difficulty of collection.

The recommendations arising out of the analysis of each item are given at the end where the agencies responsible for their implementation have also been indicated. These recommendations, it is hoped, would lead to the formulation of specific schemes of survey and utilisation of these wastes and by-products, to be included in the Fourth Plan. Some of the recommendations can be implemented in the Third Plan as they involve neither any foreign exchange nor any major industrial set-up, and it is hoped that they would receive consideration at the hands of implementing agencies. In the end I extend my thanks to the organisations, institutions and specialists who cooperated in this study.

NEW DELHI

August 7, 1963

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Indian Standards Institution

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Institutions

Central Fuel Research Institute.
Central Building Research Institute.
Indian Lac Research Institute.
Central Institute of Fisheries Technology.
Indian Central Tobacco Committee.
National Chemical Laboratory.
Central Food Technological Research Institute.
Indian Salt and Marine Chemicals Research Institute.
Central Glass and Ceramic Research Institute.

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I. RICE BRAN

During the process of rice milling, the layer round the endosperm is removed together with a portion of polishing. This separated layer is called rice bran. The outer bran layers are richer in fat while the inner layers contain more of vitamins and proteins. Bran constitutes roughly between 6-10 per cent of un-polished rice and contains oil to the extent of 15-20 per cent. In addition, it contains Vitamin B complex and important amino acids such as cystine, lysine, histidine, trytophane and arginine.

Availability of Rice Bran

The Government of India, set up a Committee on Rice Bran Oil Industry in 1960. The estimates of availability of rice bran for oil extraction and the conclusions arrived at by the Committee are given in the following paragraphs.

The quantity of bran recovered from rice varies according to the quality of raw rice used and also depends on the degree of its polishing. On the basis of various estimates made regarding the recovery of bran from rice in India, between 6-8.5 per cent of bran is recovered under the present conditions of rice milling. Taking the lower figure of recovery and on the basis of total production of polished rice in the country, theoretically about 1.8 million tons of rice bran would be available. The entire quantity is, however, not available for extraction of oil for the following reasons :

(a) A large portion of paddy is hand-pounded. The percentage of hand-pounding, according to the report of the Rice Milling Committee (1955), varies from 4.3 per cent in Mysore to 97.4 per cent in Bihar. It is generally assumed that roughly 50 per cent of rice produced in the country is hand-pounded. It would be difficult to collect bran from hand-pounded rice and in any estimates of availability from this source has to be taken as nil.

(b) As large number of small producers get their paddy de-husked from small rice mills and take back with them clean rice as well as bran which is mainly used as a cattle feed and hence is not available for oil extraction.

(c) Bran is produced in bulk only by larger rice mills which could form a source of assured supply of bran for extraction of rice bran oil.

(d) The availability of bran is also determined by the huller or the sheller system of de-husking being currently used in the rice mills. While in the sheller system, the bran and husk are separated and good quality bran is available, in the huller system the bran and husk get mixed up and unless methods are developed for separating bran and husk, the bran from the huller system would not be available for oil extraction.

The State-wise availability of rice bran, as reported by the Rice Bran Oil Industry Committee, is given in the following table :—

TABLE 1

Availability of rice bran by States

State	Estimated production of rice (1958-59)	Theoretical availability on the basis of 6% recovery	Estimates of availability made by the Committee
Andhra Pradesh	3,616	217	120
Assam	1,650	99	7·5
Bihar	4,202	252	25
Bombay :			
Maharashtra	1,261	102	52
Gujarat	448		1·077
Jammu & Kashmir	236	14	Not estimated
Kerala	881	53	5
Madhya Pradesh	3,264	196	Not estimated
Madras	3,298	198	60
Mysore	1,110	66	Not estimated
Orissa	2,036	122	Do.
Punjab	316	19	Do.
Rajasthan	84	5	Do.
Uttar Pradesh	2,976	178	10
West Bengal	4,053	243	25
Himachal Pradesh	41	2	Not estimated
Manipur	113	7	Do.
Andaman & Nicobar	5	--	Do.
TOTAL	29,721	1,781	

The quantity of rice bran which may be available for oil extraction in the country in 1960-61 may be estimated as follows :—

	Million tons
1. Total production of rice in 1960-61	33·700
2. Less 10 per cent used for sowing	3·370
	30·330
3. Less 50 per cent produced by hand-pounding (the collection of bran from which source is un-economic)	15·165
4. Total quantity of rice produced in mills	15·165
5. Production of bran on the basis of minimum 6 per cent recovery on 4 above	900,000 tons approx.

As compared to the availability of about 900,000 tons of bran for oil extraction, the total of existing and licensed annual installed capacity of rice bran oil industry is 100,000 tons in terms of rice bran. In addition, about 42,000 tons of rice bran were exported in 1961-62. There is thus scope for installing industry which could make use of the balance of about 750,000 tons of bran on the basis of its availability in 1961-62.

A target of production of 45 million tons of rice has been envisaged under the Third Plan. The production of rice has been projected by the NCAER to be 47 and 58 million tons in 1970-71 and 1975-76 respectively. With the increased production of rice and better methods of de-husking in the future years, the availability of bran is likely to be more than double by 1975-76.

The present policy of the Government is to discourage expansion of rice milling capacity and installation of new rice mills is governed under the Rice Milling Industry (Regulation) Act, 1958. Under the Act, however, powers have been delegated to the State Governments for licensing the installation of new rice mills keeping in view not only the likely effects on the existing hand-pounding industry but also the scope for its further development. It has already been mentioned that the bran available from the sheller system of rice milling is not of good quality but is available separated from husk. While licensing/setting up of rice mills in future, it should be ensured that only sheller type mills are licensed. The rice mills equipped with the huller could also be allowed to modernise by replacing the huller by shellers.

Utilisation of Rice Bran

Rice bran is at present being used chiefly as cattle feed. Raw rice bran containing a high percentage of free fatty acids causes diarrhoea when fed to cattle. It has been reported that rice bran from which high free fatty acid/oil has been removed is free from bad odour and is more acceptable to cattle. It is, therefore, advantageous from this point of view to use extracted rice bran as a cattle feed. The extraction of oil from rice bran would also give a by-product which is valuable in the context of our gradually dwindling surplus of vegetable oils. With this end in view, a target production of 50,000 tons of rice bran oil annually has been decided upon for the Third Plan.

Rice Bran oil extraction

Immediately after the rice bran is separated from rice, it begins to hydrolyse due to the presence of an enzyme called 'lipase'. The free fatty acids in the oil are below 3 per cent to begin with but increase at a rate which may be as high as 1 per cent per hour during the first few hours and at a slower rate thereafter when stored under humid conditions and at atmospheric temperatures of 25-31°C. The rate of variation of free fatty acids with the moisture content of rice bran and its period of storage has been studied at the Oil Technological Institute, Anantpur. The results are given below :—

TABLE 2

Variations of moisture, oil and acid contents of rice bran by storage periods

Storage period	Moisture per cent	Oil content per cent	Oil content m.f.b.* percent	Free fatty acid or oil present per cent
3 hours	8·2	14·2	15·5	3·0
15 days	8·3	14·2	15·5	10·7
30 days	8·5	14·1	15·4	18·2
49 days	8·4	14·2	15·5	27·0
72 days	8·5	13·9	15·2	44·3
100 days	10·5	13·8	15·4	62·5

*m.f.b. mean moisture free basis.

Several methods could be employed to arrest the activity of the enzyme lipase. Storage at low temperature is said to be effective, but is not practicable on a large scale in India. The method of de-activating the lipase and stabilising the bran which is considered feasible consists of heating the bran immediately after separation to a temperature of 100-120°C for a period of 4 to 30 minutes. This heat treatment or stabilisation destroys the active lipase and also dries the bran to a low moisture content of 2-5 per cent. Stabilised rice bran with free fatty acid content of 3-5 per cent would keep for 8 to 10 weeks.

An important factor which affects the quality of rice is the method of de-husking paddy. In the sheller system the bran and husk come off separately and thus yield bran of good quality while in the huller system, the bran and husk are mixed up. Rice is milled in hullers in West Bengal, Assam, Bihar and Uttar Pradesh and in shellers in Maharashtra, Andhra Pradesh, Mysore, Madras and Punjab. Solvent extraction of rice bran which contains large proportion of husk is uneconomical and such bran when de-oiled has a high silica content. For the purpose of export de-oiled rice bran has to be low in silica content as required by foreign purchasers.

Development of Rice Bran Oil Industry in India

The possibility of extracting oil from rice bran was first exploited in India by the Central Food Technological Research Institute, Mysore, which also set up a pilot plant for the purpose. The first unit to take up commercial extraction of rice bran was Messrs Ulhas Oil and Chemical Industries (Private) Ltd., Kalyan. At present four units each with a capacity for processing 50 tons of rice bran per day are registered under the Industries (Development and Regulation) Act. Rice bran oil industry is seasonal and can be operated on an average for only 150 working days per year and it would be reasonable to calculate the annual installed capacity of factories on this basis. Thus, the four existing units would have a total installed capacity of 30,000 tons per annum. In addition, licensed capacity aggregates to 466 tons of rice bran per day or 70,000 tons per annum on the basis of 150 working days. The total of existing and licensed annual installed capacity of rice bran oil industry is 100,000 tons in terms of rice bran.

Production of rice bran oil, which began in 1960, is given below :—

Year	Rice Bran treated (tons)	Rice Bran Oil recovered (tons)
1960	1,633	210
1961 (estimated)	11,000	1,700

Considerable quantities of rice bran are exported. Given below are the figures for the last two years :—

Year	Quantity (tons)	Value (Rs. lakhs)
1960-61	12,597	19·72
1961-62	41,615	72·37

Steps have been taken by the Government of India to develop indigenous fabrication of rice bran oil extraction plants. The capacities of the plants would be in terms of rice bran of 25 tons per day and 50 tons per day and their capital cost would be approximately Rs. 4 lakhs and Rs. 6.5 lakhs respectively. Indigenous fabricators are being permitted initially such essential parts (not exceeding 1/3rd of the total value of the plant) as cannot be fabricated within the country. A rotary type of drier for stabilising rice bran can be constructed indigenously at a cost ranging from Rs. 5,000 to Rs. 10,000 inclusive of the steam boiler.

Uses of Rice Bran Oil and De-oiled Rice Bran

Japan is the pioneer producer of rice bran oil in the world. The pattern of utilisation of rice bran oil in Japan in 1959 was as follows :—

As edible oil	5,820	tons
For use in the manufacture of margarine	2,480	,,
Soap manufacture	8,400	,,
Resin industry	13,100	,,
Miscellaneous industrial uses	2,200	,,
TOTAL	32,040	,,

In Japan about 90 per cent of de-oiled bran is used for cattle feeding and 10 per cent as fertilisers particularly in tobacco and onion plantings.

In Chile, rice bran oil is refined and used as salad oil and for cooking purposes.

Rice bran oil is used in the U.S.A. as an edible oil after refining and is considered particularly suitable for salad dressings and other emulsified products. It is also used to a small extent as carrier in insecticidal formulations. Extracted rice bran is used in the manufacture of compounded cattle feed.

In view of the likely high free fatty acid content in the initial stages in India, rice bran oil can be expected to be used for industrial purposes only. Manufacture of soap and as a raw material for splitting fat are two important uses. Experiments were carried out for the use of rice bran oil in the manufacture of soap and it was concluded that rice bran oil produces a harder soap than groundnut oil and can be used to the extent of about 20 per cent of the weight of fatty composition for a good washing soap produced by 'fully boiled' process. Further investigational work would have to be carried out for chemical bleaching of rice bran oil and removal of its wax and unsaponsifiable matter so as to make it a suitable raw material for the manufacture of quality soaps.

Rice bran oil is edible only after proper refining. Initially it may not be found possible to produce rice bran oil of edible quality. Gradually, however, as experience is gained, edible rice bran oil may be produced. Until sufficient experience is gained in refining and standardisation of rice bran oil, it should be sold only in the internal market and export should not be permitted.

De-oiled rice bran may be exported and for this purpose standardisation is very desirable. Internally, it can be used for the manufacture of compounded cattle feed containing de-corticated cottonseed cake, wheat bran, de-oiled rice bran, etc.

Rice bran occupies much space because of its fluffy nature. For reducing storage space and packing for transportation, it should be compressed. In order to prevent infestation in extracted bran, suitable preventive measures should be taken.

TABLE 3

Distribution of rice mills in various States of India

Sl. No.	Name of State	No. of mills registered under Indian Factories Act	No. of licensed rice mills
1.	West Bengal	372	485
2.	Bihar	116	148
3.	Orissa	97	114
4.	Madras	285	795
5.	Andhra Pradesh	568	796
6.	Madhya Pradesh	157	457
7.	Uttar Pradesh	49	510
8.	Assam	79	375
9.	Maharashtra	17	179
10.	Mysore	9	282
11.	Kerala		408
12.	Punjab	16	182
	TOTAL	1,747	4,731

TABLE 4

Yield of products from the milling of paddy

	per cent
Hulls	17·4—20·9
Bran	8·0—13·6
Polish	1·8— 4·0
Head Rice	39·4—65·0
Screenings	3·0— 9·3

TABLE 5

Composition of Rice Bran

	per cent
Water	8·9—12·5
Protein	10·6—13·4
Fat	10·1—22·4
N-free extract	38·7—44·3
Fibre	9·6—14·1
Ash	9·3—14·3
Starch	—
Pentosans	8·7—11·4
B-Vitamins (microgram)	544

TABLE 6

Characteristics of Rice Bran

	Raw Rice Bran	Parboiled Rice Bran
Yield (% rough rice)	6—9	6·9
Bulk density (lb/cu. ft.)	21—22·5	15·5
Sieve Analysis		
Per cent passing		
16 mesh	98·2	95·4
30 mesh	79·8	61·7
60 mesh	22·5	11·1
100 mesh	4·7	2·3
Moisture per cent	17·7—10	7·5—12·5
Oil per cent (m.f.b.)	13·9—23·0	12·1—26·4
Mean	21·1	21·6
N-free extract per cent	38—44	38—44
Protein per cent	10—13·5	10—13·5
Fibre per cent	9—14	9—14
Ash per cent	5·5—14·4	9—15·2
Silica ash per cent	11·5—29	20—30
Sugars	3—5	0—1
Pentosans	8	8
Vitamins (B) g/g	533—542	533—542
Vitamin E g/g	30	—

TABLE 7

Characteristics of Rice Bran Oil

Specific Gravity 25°C	0·912—0·920
Refr. Index 25°C	1·409—1·470
Iodine No.	98—104
Sapon. val.	174—184
Thiocyanogen val.	68—70
Titeric	27—29
Unsapon. matter per cent	3·0—5·7
Acetyl val.	8·0—10·0
Saturated acids per cent	15—18
Smoke point	415 °F
Colour	Brown to green
Tocopherol (Vit. E) per cent	0·029—0·16

TABLE 8

Compostion of Rice Bran Oil

Fatty acids	Per cent glycerides in the oil
Myrisitic	0·2
Palmitic	12—17·3
Stearic	1·8—2·6
Arachidic	0·5
Behenic	0·5
Lignoceric	0·7
Oleic	41—45·6
Linoleic	27·6—36·7
Unsaponiable matter	4—5·7

II. OIL BEARING TREES—NON-EDIBLE MINOR OILSEEDS

Besides the annually cultivated oilseed crops, India possesses about 86 different oilseed bearing perennial trees. These trees are either grown for timber or planted as avenue trees on roadside or grow in the forests etc. Because of the current shortage of vegetable oils, it has become necessary to search for other sources of vegetable oils. Non-edible minor oilseeds are a potential source of supply of these. These non-edible oilseeds have not been properly studied or surveyed in the past. At present no precise information is available with regard to the number of trees and production of seeds, but according to estimates the production of all the minor oilseeds combined together approximates about 10 lakh tons annually. The most important of the minor oilseeds are :

1. Mahua (*Madhuca indica*)
   Local names—Madhuka, Mawrah, Illupi, Illupai, Ippe.
2. Neem (*Azadirachta indica*)
   Local names—Limba, Nim, Nimba, Vepa, Veppam, Bevu.
3. Karanja (*Pongamia pinnata*)
   Local names—Pongam, Kanugo, Honge.
4. Pisa (*Actionodaphne hookeri*)
   Local name—Galawara.
5. Kokum (*Garcinia indica*)
   Local name—Amsul.
6. Kamala (*Mallotus philipensis*)
7. Undi (*Calophyllum inophyllum*)
   Local names—Punna, Pniiai, Surahonne.
8. Khakan (*Salvadora oleoides*)
   Local names—Pilu, Gore.
9. Kusum (*Schleichera oleosa*)
   Local name—Poovan.
10. Nahor (*Mesue ferrea*)
    Local names—Nageshwar, Nangal, Churuli.
11. Sal (*Shorea robusta*)
    Local name—Sakkhu.

A brief account of the availability and potential oil yield from these trees is given below :

1. *Mahua* (*Madhuca indica*) :

Mahua tree grows wild in forests and along the roads in most of the States in India. The oil content of the seed varies from 33-43 per cent of the weight of the kernel. According to the report of the Panel of Soap Industries, of the Planning Commission, about 50,000 tons of Mahua seeds are estimated to be collected annually for crushing, yielding about 20,000 tons of Mahua oil. The Indian Central Oilseeds Committee (ICOC) has collected information regarding the number of trees, actual collection of seeds, and potential production. This is given below.

TABLE 1

Number of trees, yield per tree, production and collection of Mahua Oil by States

States	No. of trees	Yield per tree	Total estimated production (tons)	Actual collection (tons)
1. Andhra Pradesh ..	9,80,700	70-100lbs. in old Madras State area, 28 lbs. in Telangana area.	6,339	4,026
2. Bihar	N.A.	N.A.	4,220*	N.A.
3. Gujarat	5,48,826	32-80 lbs. in Saurashtra area; 82-lbs. Bombay area.	15,162	6,044
4. Madhya Pradesh ..	22,23,513	60-80 lbs.	23,924	6,071
5. Madras	2,40,000	70-100 lbs.	4,700	3,200
6. Maharashtra	2,25,272	82 lbs.	5,046	2,294
7. Mysore	66,300	35 lbs. in Karnatak area; 82 lbs. in the rest.	1,896	1,235
8. Orissa	N.A.	N.A.	1,800**	N.A.
9. Rajasthan	N.A.	N.A.	1,838*	N.A
10. Uttar Pradesh ..	49,95,627	N.A.	1,49,720*	18,000
11. West Bengal	1,61,700	20-80 lbs.	2,941	N.A.
TOTAL	94,41,938		2,17,566	41,870

*Estimates by Khadi and Village Industries Commission.

**Estimates by Directorate of Economics and Statistics, Ministry of Food and Agriculture.

The collection of the seeds is carried out mostly by private parties either under a permit system or by auction and the cost of collection varies from Re. 1 per maund in Maharashtra to Rs. 10 per maund in Madhya Pradesh. The season of collection of seeds which coincides with the fruiting season, however, varies with climatic conditions. In the North it is April to June, in the States of Gujarat and Madhya Pradesh it is June-July, and in the States of Mysore, Madras and Kerala it extends from August to September. It will be seen that there is large scope for increasing production of Mahua oil provided the collection and extraction of oil from seeds is organised in a proper manner. The scope is particularly large in Uttar Pradesh and Madhya Pradesh in which there is a large gap between potential and actual production.

2. *Neem (Azadirachta indica)* :

Neem trees are also grown all over the country along the road sides and paths; but are found mostly in areas of U.P., Madras, Maharashtra, Orissa, Rajasthan, Madhya Pradesh, Punjab, Delhi and Bihar. The chief problem in the case of utilisation of neem seeds is organisation of collection and crushing of seeds. Information regarding estimated production and collection of neem is given below :—

TABLE 2

Number of trees, yield per tree, production and collection of Neem Oil by States

State	No. of trees	Yield per tree	Total estimated production (tons)	Actual collection (tons)
1. Andhra Pradesh ..	6,34,855	14 lbs. in Telangana area; 40-60 lbs. in the Madras State area.	11,473	3,128
2. Gujarat	6,17,632	26 lbs. in old Saurashtra area; 120 lbs. in old Bombay State area.	19,697	139
3. Madhya Pradesh ..	7,14,187	40-60 lbs.	17,060	368
4. Madras	24,70,000	40-60 lbs.	53,555	15,451
5. Maharashtra	6,89,419	14 lbs. in old Marathwada area; 120 lbs. in old Bombay State area.	26,397	210
6. Mysore	7,67,581	20-81 lbs.	18,804	3,700
7. Orissa	—	—	1,103@	—
8. Punjab	—	—	11,287*	N.A.
9. Rajasthan	—	—	3,676*	N.A.
10. Uttar Pradesh ..	77,40,393	—	2,49,242*	N.A.
11. West Bengal	2,65,000	50 lbs.	2,339	615
TOTAL	1,38,99,067		4,14,633	23,617

Source: Indian Central Oilseeds Committee.

*Estimates of Khadi & Village Industries Commission.

@Information from chief conservation of Forests.

It will be seen that at present a very small fraction of the annually available oilseeds are utilised.

3. *Karanja* (*Pongamia pinnata*):

These trees generally grow wild in the forest areas of Orissa, Mysore, U.P. and Andhra Pradesh. In this case also, the major obstacle in the way of utilisation of seeds is lack of systematic collection. The Karanja seeds yield an average of 28-30 per cent oil, and the oil cake can be used as a manure for paddy and for rabi crops. According to the ICOC survey, carried out in various States of India in 1949-50, the production of Karanja oil is about 34,000 tons and that of oil cake 7,900 tons. The State-wise distribution of trees, potential production of seeds and their actual collection data collected during this survey is given below :—

TABLE 3

Number of trees, yield per tree, production and collection of Karanja oil

States	No. of trees	Yield per tree	Potential production of Seeds (tons)	Actual collection of Seeds (tons)
1. Andhra Pradesh ..	19,17,710	26 lbs. in Telangana region; 50 lbs. in Madras region.	39,432	2,675
2. Gujarat	1,12,201	60 lbs. in Saurashtra; 82 lbs. in Bombay region.	3,121	399
3. Madhya Pradesh ..	89,261	30-60 lbs. in Bhopal; 20 lbs. in Madhya Bharat; 16 lbs. in Vindhya Pradesh.	1,048	176
4. Madras	18,50,000	50 lbs.	41,112	2,657
5. Maharashtra	1,53,020	40 lbs. in Marathwada area and 82 lbs. in Bombay area.	4,211	1,326
6. Mysore	2,62,161	20 lbs. in Marnatak region; 50 lbs. in Mysore region.	5,987	4,061
7. Orissa	—	—	59*	—
8. Uttar Pradesh ..	—	—	7*	—
9. West Bengal	51,600	30-40 lbs.	734	26
TOTAL ..	44,35,953		95,711	11,320

* Estimates from Chief Conservator of Forests.

4. *Pisa (Actionodaphne hookeri)* :

Pisa is a small tree found in the warm moist forest of the lower hills of Eastern and Western Ghats and in Sikkim. In Maharashtra State, it occurs mainly in Ahmednagar, Nasik and Satara districts and in Mysore in Kanara and Shimoga districts. Pisa trees flower in the months of December and January and the collection of seeds is done mostly from the middle of May to the middle of June. Along with the difficulty of organised collection, Pisa trees have a peculiar difficulty of their own *i.e.* the trees being at high altitudes become inaccessible during the rainy season. No statistical data are available for this tree.

5. *Kokum (Garcinia indica)*:

Data relating to this tree are available from the survey of the Indian Central Oilseeds Committee, only for the areas of the former (Pre-1956), Bombay State only. The tree grows mainly in the coastal districts, from Surat in the north to North Kanara in the south. According to the survey carried out by Indian Central Oilseeds Committee, the total number of Kokum trees in the former State of Bombay were estimated to be about 56,600 distributed mainly in the districts of Ratnagiri, Kanara and Surat. A Kokum tree yields about 12 seers of seed annually and the cost of collection is estimated at Rs. 3 per maund. The oil percentage is about 20. State-wise distribution of trees and potential production of oil seeds is given below :—

TABLE 4

Number of trees, yield per tree, production and collection of Kokume Oil Seeds by States

State	No. of trees	Yield per tree	Potential production (tons)	Estimated collection (tons)
1. Gujarat (Area from old Bombay State).	1,278	25 lbs.	10	10
2. Maharashtra (Area from old Bombay State)	42,997	25 lbs.	357	357
3. Mysore	2,332	25 lbs.	104*	19
TOTAL ..	46,607		471	386

Source: Indian central Oilseeds committee.
*Chief Conservator of Forests, Mysore State.

6. *Kamala (Mallotus philipensis)* :

The Kamala trees occur in the forest areas in various parts of India but estimates of their numbers have been made by the Indian Central Oilseeds Committee for only two States, West Bengal and the former Bombay State. The number of trees in West Bengal (Jalpaiguri and Darjeeling districts) were estimated at about 93,000 and in the former Bombay State at about 15,000. The yield rate of seed per tree was estimated at about 8 seers in case of Bombay and from 1½ to 5 seers in case of West Bengal. In Bombay, the seeds are generally collected by a tribal people, the Lamanis, and sold to merchants. Kamala contains about 50 per cent of Komolenic acid which is a good raw material for industrial products. The National Chemical Laboratory have done a considerable amount of work on its chemical and technological properties. But extraction of oil on a commercial basis is not yet organised.

7. *Undi (Calophyllum inophyllum)*:

The tree grows over large areas in the coastal and central regions as well as hilly tracts of Peninsular India. There are two species—Inophyllum and Wightiana, the trees and seeds of the former are larger in size and bear fruit twice a year, while the latter bears only once in two or three years. The oil content of both the species is about 60 per cent; though varieties yielding even higher percentages are found in the Northern part of Kerala State. These trees are also used as standard for pepper vine cultivation and for honey extraction as the

Calophyllum flower attracts honey bees in large numbers. The average adult tree yields about 12,000 fruits at each of the two seasons from February to May and September to November. Table 5 gives state-wise distribution of trees, yield per tree, potential production of seeds and actual collection.

TABLE 5

Number of trees, yield per tree, production and collection of Undi Seed

State	No. of trees	Yield per tree	Potential produc-tion (tons)	Actual collec-tion (tons)
1. Kerala	1,56,220	48 lbs. in Travancore Cochin. 35 lbs. in Madras Area.	2,421	230 (Madras area)
2. Madras	47,000	35 lbs.	705	470
3. Maharashtra	8,596	25 lbs.	71	57
4. Mysore	41,019	35 lbs. in Madras area 25 lbs. in Mysore area	542	374
5. Orissa	—	—	59@	—
TOTAL ..	2,52,835		3,798	

Source : Indian Central Oilseeds Committee.
@Chief Conservator of Forest, Orissa State.

8. *Khakan* (*Salvadora oleoides*) :

The Khakan tree grows in dry, sandy and saline tracts of Central and Western India, Northern Gujarat, Rajasthan, Madhya Pradesh and the Punjab. The fruit is harvested from June to July. According to the survey carried out by Khadi and Village Industries Commission, the total availability of Khakan seeds is about 46,000 tons as detailed below :

	Potential production of Khakan seeds (tons)
1. Gujarat	44,118
2. Madhya Pradesh	720
3. Punjab	18*
4. Rajasthan	1,087
	45,943

*Chief Conservator of Forest, Punjab.

9. *Kusum* (*Schleichora oleosa*) :

The tree is found in dry forests in most parts of India, Burma and Ceylon. It occurs in the sub-Himalayan region of N. India from

Punjab to Nepal and throughout Peninsular India, Central India, the East and West coast regions, the Deccan and Karnatak. The information collected by the Indian Central Oilseeds Committee regarding quantities of seed available, and actually collected, is given below :—

TABLE 6

Quantity of Seeds, area where available and quantity of Kusum Seeds by States tons

State	Quantity of seeds available	Area where available	Quantity of seeds collected
1. Bihar	N.A.	Data	not available
2. Kerala	3	Nilambur area.	—
3. Madhya Pradesh ..	149	Kanker, Drug, S. Bastar, Raigarh, S. Raipur, N. Raipur, Bilaspur districts.	—
4. Mysore	197	Sirsi, Siddapur and Kumta ranges.	—
5. Orissa	184	Mayurbhanj & Keonjhar districts.	92
6. Uttar Pradesh	0·5	Bahraich & North Kheri districts.	—
7. West Bengal	401	N.A.	59
TOTAL ..	934·5		151

Source: Indian Central Oilseeds Committee.

Since the Kusum tree serves as a host for lac insect it is being cultivated in compact blocks which makes its cultivation easy and economical. The oil content in the kernel is about 57 per cent.

10. *Nahor* (*Mesua ferrea*):

Nahor tree occurs in abundance in the forests of the Himalayas in Assam and West Bengal, along the wetter slopes, Western Ghats especially in Kerala and in the Andaman islands. In the plains, it is found chiefly as an ornamental tree, under various local names. The total number of trees in Assam State alone are estimated to be about 6,20,000 with an average yield of about 10 seers of seed per tree. The potential production of oil therefore, works out to 5,698 tons. Dr. J. A. von Monroy in his report on Integration of Forests and Industries has suggested establishment of a Nahor oil plant in Assam.

11. *Sal* (*Shorea robusta*):

Sal tree is found in the sub-tropical sub-Himalayan region from the Punjab to Assam; in the forests of Eastern India in Bihar, West Bengal, Orissa and Eastern Madhya Pradesh. Information regarding availability of Sal seeds in different States is summarised below :—

TABLE 7

Quantity of available, area and quantity collected of Sal Seeds

State	Quantity available (tons)	Area where available	Quantity collected (tons)
1. Assam	1,72,478	Goalpara East and West Division.	Collected for regeneration of Sal.
2. Bihar	N.A.	N.A.	N.A.
3. Madhya Pradesh ..	36,811*	Surguja, Raigarh, S. Raipur, Balaghat, Bilaspur, and N. Raipur.	N.A.
4. Orissa	2,206	N.A.	N.A.
5. Uttar Pradesh	735	N.A.	Collected only for regeneration of Sal.
6. West Bengal	N.A.	N.A.	N.A.
	2,12,230		

**Source*: Indian Central Oilseeds Committee.

Since afforestation work is being carried out in certain parts of the country, the seeds are not collected for oil extraction purposes.

Availability of non-edible Oilseeds

According to information given above and compiled on the basis of data furnished by various sources to the Indian Central Oilseeds Committee, the total potential availability of more important non-edible oilseeds is estimated at one million tons, distributed as follows :

Oilseed	Quantity (tons)
Mahua	2,12,566
Neem	4,14,633
Karanja	95,711
Undi	3,798
Khakan	45,943
Pisa	340
Kokum..	471
Kusum	934
Nahor	5,690
Sab	2,12,230
TOTAL ..	9,92,316=10,00,000 (approx.)

Present uses of non-edible oils

The greater part of the production of non-edible oilseeds is crushed in village ghanis and the oil is put to such uses as burning in lamps, manufacture of soap, use in folk medicines etc. Besides this, there is a certain amount of commercial crushing by mills. The quantity of seeds crushed and oil and cake produced by mills are given in Appendix I. Recent studies conducted at the National Chemical Laboratory, Poona, the Regional Research Institute, Hyderabad, the Harcourt Butler Institute of Oil Technology, Kanpur, the Forest Research Institute, Dehra Dun, the Oil Technology Institute, Anantapur and the All India Khadi & Village Industries Commission show that besides yielding oil, these non-edible oilseeds could also be source of supply of a number of other useful products. The major uses of each of these oilseeds are indicated in Appendix II.

There are certain other fats which can be conveniently separated from the component acids and used for various industrial purposes, like manufacture of soap, varnish, textiles, rubber, cosmetics, and cleansing agents. Next in importance to fats and fatty acids are the non-glyceridic by-products which could be conveniently separated from the *lipids* and used for preparation of medicines and fungicides.

The Indian Central Oilseeds Committee and the Khadi and Village Industries Commission are the two principal organizations concerned with utilization and economic exploitation of these minor non-edible oilseeds.

The Khadi and Village Industries Commission which has a special unit to look after both the technical and economic problems pertaining to utilisation of these oilseeds, had, during the Second Plan period, undertaken a development programme with a two-fold objective, *viz.*, collection, storage and crushing of non-edible oilseeds and utilisation of the oil obtained from them for manufacture of soap. The programme envisaged financial assistance for organisation of production centres of different capacity graded into "A" (with an annual productive capacity of 30 tons), "B" (15 tons) and "C" (8 tons); training of personnel for newly established centres and technical and other assistance to schools for introducing manufacture of soap with non-edible oils as one of the crafts. The quantities of oilseeds collected and of the oil produced from 1955-56 to 1960-61 under the programme of the Commission are given in Appendices III & IV. The production of soap increased over six-fold, from 5.35 lakh lbs. to 34.29 lakh lbs. between 1955-56 and 1958-59; Bombay accounting for 9.10 lakh lbs., Punjab 5.05 lakh lbs., Rajasthan 3.6 lakh lbs., Mysore 2.53 lakh lbs., and Madras, Uttar Pradesh and West Bengal for over 2 lakh lbs. each. During this period, sales of soap also expanded from 2.3 lakh lbs. to 30.19 lakh lbs.

The programme undertaken during the Third Plan period is based on the results of research and experiments initiated in the earlier years particularly in respect of storage and preservation of seeds, and processes for more efficient extraction of oil. The quality of the soap has also improved as a result of adoption of the Indian Standards Institution's formula. By and large, 'C' type of production units have been found to be more popular than the larger ones. As against 34.29 lakh lbs. in 1958-59, the production of soap had increased to 58.5 lakh lbs. in 1961-62. The quantities of non-edible seeds and oils proposed to be collected under the programme of the Khadi and Village Industries Commission during the Third Plan period are indicated in Appendix V.

The Indian Central Oilseeds Committee did pioneering work in carrying out a Survey to collect basic data about the availability of these oilseeds throughout the country. Recently the Committee in collaboration with All Indian Non-edible Oil Industry Association, Poona, have drawn up a scheme for promotion of collection of non-edible oilseeds. The annual targets of collection of important oilseeds non-edible oilseeds under this scheme are given in the Appendix VI.

Problems of Utilisation

The major problem in utilization of most of these non-edible oilseeds is the cost and difficulty of collection. Several of the trees are found in forest areas, often scattered among a large number of other species, or are located in areas having difficult communications. Even trees like Neem and Mahua which are found mainly in non-forest areas are scattered along roads and in cultivated fields, and are not found in compact blocks. As a result, collection has to be made over large areas. Moreover in case of forest trees it is generally done by backward and tribal people and is not organised. In case of Mahua there is the further difficulty created by the fact that Mahua flowers can be fermented and used for distillation of liquor. As a result, most State Governments have not encouraged growing or protection of the Mahua trees after adopting the policy of prohibition; and in some States, *e.g.* Madhya Pradesh, their number has been grealty reduced as a result of indiscriminate felling, and check on further planting.

The second difficulty is that of processing. The oil industry is geared at present to processing of cultivated oilseeds. It has not yet been developed to process the non-edible oilseeds and in the case of a number of them, certain technical problems *e.g.* those concerned with refining and bleaching of oil will have to be solved before extraction can be organised on a commercial scale. Utilisation of the by-products for industry will also involve further work at the National Laboratories and other Institutions to perfect processes which can be economically used.

But as explained in the beginning, use of these oilseeds can make a significant contribution towards meeting the expanding demand for oilseeds and other sources of fat. The supplies of cultivated oilseeds are already inadequate to meet the domestic demand, which moreover is expected to increase with growth of population and rise in standards of living. During the Second and Third Plan period, as a result of the work done by the Khadi and Village Industries Commission, progress has been made in increasing utilisation of these oilseeds especially for production of soap. The work of the Indian Central Oilseeds Committee and the technical institutions mentioned above has resulted in better knowledge about the location of these oil bearing trees and of the possibilities of their economic utilisation for extraction of oil and manufacture of industrial products. Further work along these lines is necessary to increase utilisation of these oil seeds.

APPENDIX I

Statement showing crushing of non-edible oilseeds and production of oil in mills during 1954-55 to 1957-58 (tons)

	Neem			Mahua		
	Seed crushed	Oil produced	Cake produced	Seed crushed	Oil produced	Cake produced
1954-55 ..	4,396·7	548·3	1,341·0	21,853	7,071	13,143
1955-56 ..	2,181·3	354·6	1,737·4	30,192	10,419	18,627
1956-57 ..	2,975·5	658·6	2,224·3	41,691	14,640	25 824
1957-58 ..	3,391·7	747·9	2,307·9	57,963	18,600	35,301

	Karanja		
	Seed crushed	Oil produced	Cake produced
1594-55	2,518	406	975
1955-56	6,289	1,704	3,435
1956-57	4,085	1,177	2,773
1957-58	316	902	201

Source : Indian Central Oilseeds Committee.

APPENDIX II

Statement showing major uses of non-edible oilseeds

1. Mahua —Soap, greases, softener in wooden textiles, edible purposes.
2. Neem —Soap, medicinal.
3. Karanja —Medicinal, leather tanning.
4. Undi —Medicinal, leather tanning, lubricant for cart wheels.
5. Kusum —Soap, hair oil.
6. Khakan —Soap, dyeing industry.
7. Kokum —Edible, soap.
8. Nahor —Medicinal, soap.
9. Pisa —Soap.
10. Sal —Soap, edible.

Source : Indian Central Oilseeds Committee.

APPENDIX III

Statement showing minor oilseeds collected during 1960-61 (tons)

Name of the oil	1955-56 to 1958-59	1959-60		1960-61	
		Direct	Indirect	Direct	Indirect
1. Neem	2,829·0	991·5	N.A.	3,034·3	1,868·2
2. Mahua	280·5	796·2	N.A.	263·7	724·9
3. Khakan	4·0	—	—	—	—
4. Karanja	17·4	28·1	N.A.	53·6	8·3
5. Undi	64·5	—	—	—	—
6. Pisa	47·2	—	—	—	—
7. Others	—	35·6	N.A.	7·7	202·8
	3,242·6	1,851·4	N.A.	3,431·4	2,804·2

Source : Khadi and Village Industries Commission.

APPENDIX IV

Statement showing the quantity of oils produced during 1958-59 to 1960-61 (tons)

Name of the oil	1955-56 to 1958-59	1959-60		1960-61	
		Direct	Indirect	Direct	Indirect
1. Neem	241·2	121·3	N.A.	30·9	112·1
2. Mahua	68·7	16·1	N.A.	36·2	217·5
3. Karanja	26·3	2·4	N.A.	5·9	2·1
4. Khakan	2·8	—	—	—	—
5. Undi	4·1	—	—	—	—
6. Others	N.A.	29·0	N.A.	26·1	34·7
	243·0	168·8		99·1	366·4

Source : Khadi and Village Industries Commission.

APPENDIX V

Statement showing targets of production of non-edible, oilseeds and oils during the Third Five Year Plan

TARGETS* (*tons*)

Year	Neem Seed	Neem Oil	Mahua Seed	Mahua Oil
1961-62	83,103	6,309	12,474	3,742
1962-63	84,809	6,514	12,739	3,822
1963-64	86,515	6,719	13,004	3,901
1964-65	88,220	6,960	13,268	3,981
1965-66	89,926	7,128	13,533	4,060

Year	Undi & Karanja Seed	Undi & Karanja Oil	Pilu & Pisa Seed	Pilu & Pisa Oil	Total Seed	Total Oil
1961-62	5,776	1,647	5,945	1,783	107,289	13,481
1962-63	7,482	2,074	7,820	2,346	112,850	14,758
1963-64	9,187	2,500	9,695	2,908	118,401	16,028
1964-65	10,893	2,927	11,570	3,471	123,951	17,339
1965-66	12,599	3,353	13,445	4,033	129,503	18,574

**Source* : Khadi and Village Industries Commission.

APPENDIX VI

*Statement showing targets fixed under the scheme for promotion of collection of non-edible oilseeds**

	1st Year (Mds.)	2nd Year (Mds.)	3rd Year (Mds.)
Neem fruit	28,000 (1029·4 tons)	42,000 (1,544·1 tons)	56,000 (2,058·8 tons)
Mahua kernel	4,400 (161·8 tons)	4,600 (242·6 tons)	8,800 (323 .5 tons)
Karanja kernel	2,400 (88·2 tons)	3,000 (110·3 tons)	4,800 (165·5 tons)
Pisa seeds	300 (11·0 tons)	450 (16·5 tons)	600 (22·1 tons)

*Indian Central Oilseeds Committee.

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APPENDIX VII

Statement showing physico-chemical properties of non-edible oils

Physico-Chemical Properties	Mahua	Neem	Karanja	Callophylum inophylum	Pisa	Khakan	Kusum	Nahor	Sal
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)	(9)	(10)
Specific gravity	0·92	0·9189	0·9273	0·9415 0·9452	0·925	0·9205	0·9099	0·922	0·8692
Refractive Index	1·46	—	1·4774	1·4699	1·449	—	1·4607	1·4674	1·4579
Acid Value	5·40	4·0—16·0	7·5	27—78	4·0	2·02	31·3	10·0	10·6
Saponification value ..	187—194	193·0	187·5	191—202	255·5	247·2	234·3	196·0	190·0
Iodine value	58—63	75·0	82·9	82—98	10·9	14	60·2	90·0	37·9
Unsaponifiable matter ..	1·5 to 3·0	2·0%	2·6%	0·25. 1·4%	1·92%	—	2·1%	3·2%	0·87%
Setting point (°C) ..	18—25	—	—	—	—	31·1	—	—	—
Melting point (°C) ..	23—31	—	—	—	43—44%	—	—	—	34·7
Tirtre of fatty acid (°C) ..	38—40	—	—	—	—	—	—	—	53·4
Acetyl value	—	—	14·5	—	11·3	—	4·0	—	—
Colour		— 40Y/6 R	—	—	—	—	—	—	—
Hemmer value	—	88·7 In 1″ Cell.	—	—	—	—	88·7	—	94·2

Source : Tabulated from a note by Indian Central Oilseeds Committee.

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III. TOBACCO WASTE AND TOBACCO SEEDS

India produces 3 to 3¼ lakh tons of tobacco annually, worth about Rs. 45.50 crores, and ranks as the third biggest tobacco producing country in the world, U.S.A. and China being the first and second. The total acreage under tobacco in the country in 1961-62 was 10,25,000 acres. Andhra Pradesh and Gujarat are the two most important tobacco growing States with areas of 3.75 and 2.25 lakh acres respectively. Other important producing States are Mysore, Madras, Maharashtra, U.P., West Bengal and Bihar. Details of acreage and products, under tobacco cultivation in each State are given in Appendix I.

Tobacco grown in India is broadly classified as *Nicotiana rustica* and *Nicotiana tabacum*. The principal varieties of *Nicotiana rustica* are "Motihari" grown in West Bengal, "Vilayati" grown in Bihar, and "Calcutta" grown in Uttar Pradesh, Punjab, Gujarat and Maharashtra. These varieties are used mainly for hokah, chewing, and as snuff. *Nicotiana tabacum* is the more commonly cultivated species all over the country, particularly in Andhra Pradesh, Gujarat, Mysore, Madras and Maharashtra. The important varieties of *Nicotiana tabacum* are Virginia tobacco used for memfoduri of cigarette and macingly grown in Andhra Pradesh, bidi tobacco grown in Gujarat, Mysore and Maharashtra and chewing and cigar tobacco grown in Madras.

In case of the bidi, chewing and cigar tobaccos, which are produced in Gujarat, Mysore, Maharashtra and Madras State there is no problem of production and utilisation of seed, because of the prevalence of the practice of topping. The bulk of the plants are topped and are not allowed to flower and seed, in order to produce the quality seed required by industry and only the small numbers required to produce the seed for the next crop are allowed to seed. But in case of the Virginia tobacco produced in Andhra there is a problem of utilisation of tobacco seed; because until recently all the plants were allowed to flower and seed. The seed needed for the next years' crop was collected and utilised, and the rest was allowed to go waste except where there was a needy market for it. About 90% of the tobacco seed comes from Andhra.

But in recent years, the practice of topping has been spreading in the Andhra area also, as this is considered necessary for producing quality leaf required by the cigarette industry. Therefore, the quantity of seed available is going down, and is likely to go down further in future. It is estimated that an acre of Virginia tobacco crop when allowed to seed, yields about 125 to 150 lbs. of tobacco seeds. On this basis, the maximum potential for seed production in the country works out to about 13,000 to 15,000 tons. But this would go down as the practice of topping Virginia tobacco spreads.

The oil content of the seeds is 35-37%; but commercial expellers do recover more than 27-28%. Based on this recovery figure, 13,000 tons of seeds would give about 3,500 tons of oil and 9,500 tons of seed cake. The extracted oil is slightly greenish-yellow in colour and is free from toxic principles such as nicotine and nornicotine. Solvent extraction gives higher yield of oil. But some workers have reported that oil extracted by solvents has a bitter taste. This may be due to the tobacco dust which comes along with the seed. To avoid this, multiple extraction of seed with hot water at 50°C which eliminates nicotine and other bitter constituents is carried out before expression. The extraction of the oil is carried out mostly in Guntur, Vijayawada and Rajahmundry districts in Andhra Pradesh and is done mostly by expellers. The production and utilisation of tobacco seed and oil from 1958-59 to 1961-62 are as given below.

TABLE 1

Production and utilisation of tobacco seed and oil by years

(Metric tons)

Production and utilisation of Tobacco seed and oil	Years			
	1958-59	1959-60	1960-61	1961-62
1. Tobacco seed available for collection for commercial purposes	8,636	6,858	6,271	5,809
2. Tobacco seed actually collected for extration of oil	6,613	5,050	4,157	4,568
3. Production of seed oil	1,541	1,212	1,039	1,137
4. Production of seed cake	5,072	3,837	3,118	3,431
5. Export of seed oil	1,219	371	790	327
Value Rs. (Lakhs)	9·5	5·2	11·7	5·7

Tobacco seed oil is on the border line between drying and semi-drying oils and is remarkably similar to safflower seed oil (Kardi oil) which is the main edible oil in Maharashtra, and the Telangana area of Andhra Pradesh.

TABLE 2

Characteristic of tobacco seed oil and safflower seed oil

Characteristics of Tobacco seed oil	Tobbaco seed oil	Safflower seed oil
Sp. gr. at 25°C	0·9216	0·924
Ref. index	1·4684—1·483	1·4679—1·4693
Viscosity in poises	0·5	0·5
Iodine value	130—154	132—150
Sap. value	186—197	186·2—194.
Acid value	1·2—9·8	0·5—5·6
Unsaponifiable matter	0·5—1·2%	0·59%
Titre	18—18·2	16—17
Saturated acids	9—10%	5·9%
Unsaturated acids	82·84%	87·7%
Oleic acid	25—26%	30·1%
Linoleic acid	55—70%	63—64·8%
Palmitic acid	3—5%	4·8%
Stearic acid	4—5%	2·9%
Myristic acid	0·2—0·5%	0·04%
Arachidic acid	0·1—0·3%	0·4%
Linolenic ..	1·2—2·4%	1·14—5·7%

Results of investigations on the composition and characteristics of oils obtained from different samples of seed are given in Table 3. In all cases, oil was extracted by light petroleum solvents.

Percentage of non-saponifiable matter varied from 1.8 per cent to 2.3 per cent and saturated acids from 8.0 to 13.0. In case of a few samples the oil was also extracted by pressing the seed meal in the laboratory hydraulic press at 60-70 and at a pressure of 101 tons/sq. in. Acid values, sap, values and iodine values of these oils—were found to be 1.3—1.8, 189.0—192.8 and 135.0—142.9 respectively.

TABLE 3

Composition and Characteristics of Oils from Different Sources

Sl. No.	Variety*	Locality	Oil content (%)	Acid V	Sap. V	I.V.	Linoleic acid	Linolenic (%)
1.	Val Monnai ..	Vedasandur	40	1·7	193·0	142·4	69·0	2·4
2.	Vella Vazhai ..	Vedasandur	38	1·2	191·0	140·2	67·0	1·9
3.	Natu	Guntur	37	1·3	190·2	140·0	67·0	2·2
4.	Chatham	Rajahmundry	36	1·4	190·6	142·0	70·0	2·3
5.	Harrison Spl. ..	„	33	1·6	188·4	136·0	65·0	1·8
6.	S. 20	Nipani	37	1·2	188·2	136·7	67·0	1·3
7.	K. 49	Anand	36	1·4	187·8	135·4	66·0	1·4
8.	K. 49	Baroda	33	1·3	187·2	136·2	64·0	1·2
9.	N. P. 18	Pusa	37	1·1	188·1	134·5	6·20	1·1
10.	Bori Bargama ..	Pusa	38	1·4	189·2	136·3	65·0	1·3
11.	Bori Boso-Kukouli	„	38	1·5	190·5	138·8	68·0	1·3
12.	Bori Bokarao ..	„	41	1·6	189·9	140·3	67·0	2·4
13.	N.P. 28	„	40	1·5	188·7	140·2	68·0	2·2
14.	N.P. 58	„	41	1·3	189·4	138·4	68·0	1·6
15.	N.P. 63	„	43	1·4	190·2	138·4	64·0	1·2
16.	N.P. 70	2	42	1·55	191·4	140·4	68·0	1·2

*Samples collected by Director of Tobacco Research, Rajahmundry, Andhra Pradesh (1951-52 season).

It can be observed from the results that India tobacco seed oil obtained from seeds grown in different parts of the country is sufficiently uniform in its composition and characteristics.

Suitability of the oil for edible purposes :

It is evident from the comparative data on composition and characteristics of tobacco seed oil and safflower seed oil that tobacco seed oil can safely be used for edible purposes. Its nutritive values have already been thoroughly investigated. High percentage of "essential" fatty acids present in this oil makes it quite suitable for edible purposes. There are references as early as 1920 that tobacco seed oil was used for edible purposes in Bulgaria. Due to the shortage of edible oils in Europe during World War II other countries like Germany, Hungary and Greece used this oil for edible purposes without any ill effects on the consumers. Systematic investigations have proved that its digestibility is as good as butter fat.

Uses as an Industrial Raw Material :

Tobacco seed oil has been investigated at National Chemical Laboratory for purposes of (1) preparation of coating composition having a wrinkle finish and for coating textile bobbins and (2) preparation of factice.

Wrinkle Finishes : A detailed study was carried out on the preparation and uses of tobacco seed oil fatty acid modified alkaloid for developing wrinkle forming compositions. It was found that film obtained from benzene solution of the alkaloid with a suitable drier, when baked at 120-150°C for 45 minutes to 2 hours, acquire a wrinkle pattern of uniform texture. The nature and uniformity of the wrinkle pattern depends on the composition of the alkaloid, amount of drier, thickness and uniformity of the coated film, temperature, and time of baking etc. A certain minimum film thickness is essential to produce wrinkles and these tend to be heavy with increase in thickness (References 3 & 4).

Coating of Textile Bobbins : A special urea formaldehyde resin composition was prepared and a suitable blend of this resin and tobacco seed oil fatty acid modified alkaloid was prepared for coating the bobbins. The coating was cured by baking at a temperature of about 95°C. The bobbins so coated did not warp on immersion in hot water and exposure to steam.

2. *Factice from Tobacco Seed and Safflower Oils.*

Factice is obtained by treating vegetable oils with sulphur monochloride or sulphur and is widely used as a compounding ingredient for rubber. When sulphur monochloride is employed, a colourless product (white factice) and when sulphur is used, a dark brown coloured product (brown factice) is obtained. The oils that are commercially used for the manufacture of factice include rape seed, linseed, cornseed, soyabean, castor seed, besides some fish oils. Tobacco seed oil has been utilized for the production of both white and brown grades of factice.

Seed Cake :

A number of workers have analysed tobacco seed cake reporting varying results. This may be due to the difference in sample of seeds obtained from various sources. A typical example of the analysis, reported by T. Paris (6) is given below :—

TABLE 4

Characteristics of Tobacco seed cake

Proteins	26—28%
Oil	1-2%
Carbonhydrates	30—32%
Cellulose and fibrous material	20%
Ash	6-7%
Nitrogen	3-4%
P_2O_5	7—15%
K_2O	5·47%

Tobacco seed cake is a cheaper cake than other oil seed cakes for manurial purposes. Feeding experiments have shown that the cake can be fed to livestock with success and without any deleterious effect, as reported by P. N. Orlov (7). Its nutritional values were investigated systematically on rats also with good and encouraging results. It can also be used in the plastics industry.

Tobacco Wastes :

The Tobacco wastes in the country result from processing of tobacco like bidi, chewing and hookah and handling in case of Virginia and other air cured tobaccos. At present, large quantities of tobacco wastes are used as manure and for other agricultural purposes *viz.*, insecticides etc. and some quantities are destroyed, being unfit for human consumption.

The Statewise figures for tobacco wastes for the year 1961-62 are given below :

TABLE 5

Particulars of Tobacco Waste by States

(Quantity in Kilograms)

States	Agricultural purposes	Destruction	Stalks and stems	Total
(1)	(2)	(3)	(4)	(5)
Uttar Pradesh	396,553	933,325	7,694,880	9,024,758
Madhya Pradesh	59,020	93,386	94,213	246,619
West Bengal	1,050	53,226	190,674	244,950
Orissa	27,858	21,561	7,179	56,598
Bihar	102,875	205,162	2,608,364	2,916,401
Punjab	385	98,625	136,636	235,646
Gujarat	17,676,514	171,163	711,541	18,559,218
Maharashtra	939,321	124,235	65,930	1,129,486
Madras	1,737,310	380,611	3,243,105	5,361,026
Andhra Pradesh	16,939,592	156,793	1,499,898	19,496,283
Assam	—	86	178	264
Mysore	2,404,798	88,505	1,260,224	3,771,583
Rajasthan	17,074	86,530	48,180	154,576
Jammu and Kashmir	—	1,238	36,654	37,892
Kerala	24,998	11,957	32,814	69,769
Delhi	—	36,574	271,060	307,534
Tripura	—	—	—	—
TOTAL	41,227,348	2,462,877	17,901,530	61,591,755

Source: Central Board of Revenus New Delhi.

It will be seen from the above data that 41,227,348 kgs. of tobacco wastes have been utilised for agricultural purposes. This constitutes about 70% of the total wastes. A quantity of 2,462,877 kgs. which was destroyed might ultimately be used for manuring purposes. A quantity of 17,901,530 kgs. of stalks and stems were available as waste and might have been destroyed either for burning purpose or for some other use. The tobacco waste utilised for agricultural purposes contain Nitrogen ranging from 0.5 to 1.5 per cent and is mostly utilised for manuring of cereal crops and for insecticidal purpose. Its use as a manure for crop like bidi tobacco has however been found to be harmful, as it affects the quality of the produce adversely.

It will be seen from the above table, that Andhra Pradesh and Gujarat are the two States where tobacco wastes are available in large quantities. Accordingly, these States are suitable for location of industries using these wastes.

Industrial uses of tobacco wastes

Nicotine Sulphate

The average nicotine content of the tobacco dust, stalk, mid-ribs etc. which has been analysed in the National Chemical Laboratory, ranges from 1 to 3 per cent. The process which has been worked out in the National Chemical Laboratory for the extraction of nicotine sulphate from tobacco waste has been patented.

Processes can be divided into three steps :—

A. Extraction of nicotine with water.

B. Liquid extraction of nicotine with kerosene.

C. Fixing the nicotine as sulphate and recycling the kerosene.

A. The dry tobacco or tobacco waste is powdered to about 20-30 mesh, and mixed with about 8-9 per cent of powdered lime (75 per cent). Water equal to the weight of tobacco powder is added and mixed properly. The mixture is fed into extractors and by percolation with water in the ratio of 1 : 3, or more if required, and the nicotine is extracted. The resulting broth has a pH of 10.5 in which condition the nicotine is in a free state.

B. The broth is taken in a tank fitted with baffles, stirrer and heating arrangements. The broth is heated to 40-45°C; kerosene equal to half the volume of the broth is added and the extraction carried out for one hour. After settling, the kerosene containing nicotine is separated and the broth re-extracted for the second time. Each batch of broth is extracted three times.

C. The kerosene containing nicotine is stirred in a tank with calculated amount and strength of sulphuric acid so as to give nicotine sulphate solution containing 40 per cent nicotine. The kerosene, with about 2 per cent loss, is recycled.

A factory working according to this process with one tonne of tobacco waste per day, containing 2 per cent nicotine, can produce about 45 kg. of nicotine sulphate solution. Assuming a price of Rs. 137.50 per tonne of tobacco waste, the approximate cost of production of nicotine sulphate comes to Rs. 8.00 per kilogram. If the nicotine content of tobacco is more than 2 per cent, the cost of production will be considerably lower.

The following two firms have been given licences by the National Research Development Corporation for the production of nicotine sulphate :

(a) Tobacco Bye-Products (Pvt.) Ltd., 8-1/8, Pattabhipuram, Andhra Pradesh.

(b) Urkakunj Tobacco Bye-Products, Bapuji Building, Dharamaj, Dt. Kaira, Gujarat State.

The "Tobacco Bye-Products (Pvt.) Limited had started production on an experimental scale. Owing, however, to the high cost of production they had stopped production and taken up experiments with a view to reducing the cost of production. These are understood to have shown signs of improvement.

It is understood from the Urkakunj Tobacco Bye-Products that the design of the plant and the process was being reconsidered by the National Chemical Laboratory as the tobacco wastes of the Charotar tract in Gujarat which this firm was to have used were found to contain a higher percentage of Nicotine than normal, for which the process had been originally designed by the National Chemical Laboratory.

This suggests that further work in evolving a process for extraction of nicotine sulphate is necessary and that the manufacture of nicotine sulphate could be taken up successfully only if the process is modified to utilise it on a commercial scale. Further, research work on the possibilities of manufacturing nicotine-amide and nicotinic acid, which are at present imported is necessary as the scope of the industry for the manufacture of nicotine sulphate, which is the basic product, increases with the addition of these items.

It is understood that the demand for nicotine sulphate in the country is of the order of 2500 lb. which can be met by 25 days working of any of the two factories. Assuming that the demand grows 10 times, one year of working of any one of the factories can meet the home demand.

Besides nicotine sulphate, nicotinic acid worth Rs. 2,50,000 was imported in 1961-62. Manufacture of nicotinic acid can also be undertaken as a bye-product of the nicotine sulphate industry. However, the industry has only a limited potential.

The situation would however change if it becomes possible to produce nicotine sulphate and nicotinic acid cheap enough to export the same at competitive rates in foreign markets, because there is a large demand for these in markets abroad.

Summary :

Under the existing practices of cultivation of different types of tobacco in the country, there is very limited scope for developing tobacco seed oil industry as a bye-product industry. This and the manufacture of nicotine sulphate etc. can however be developed as complementary industries, if the demand for the latter increases and if exports of these can be built up.

Research to modify the present process of extraction of nicotine sulphate is necessary to make it more efficient and economical for manufacture of nicotine sulphate from tobacco wastes on a commercial scale.

APPENDIX I

All-India Final Estimate of Tobacco, 1961-62

State/Variety	Area (Thousand Acres) 1961-62 (Final Estimate)	Area (Thousand Acres) 1960-61 (Partially Revised Estimate)	Production (Thousand Tons) 1961-62 (Final Estimate)	Production (Thousand Tons) 1960-61 (Partially Revised Estimate)
(1)	(2)	(3)	(4)	(5)
Andhra Pradesh				
Nicotiana tabacum				
(*i*) Virginia	231	213	68	64
(*ii*) Others	155	142	56	52
TOTAL	386	355	124	116
Stalks and Stems	—	—	123	111
Assam				
Nicotiana tabacum	24	24	7	7
Bihar				
Nicotiana	22	20	8	7
Nicotiana tabacum	21	19	7	5
TOTAL	43	39	15	12
Jammu & Kashmir				
Nicotiana tabacum	1@	1	(b)@	(b)
Gujarat				
Nicotiana rustica	1	1	1	1
Nicotiana tabacum	228	215	82	58
TOTAL	229†	216†	83†*	59†*
Kerala				
Nicotiana tabacum	2	2	1	1
Madhya Pradesh				
Nicotiana tabacum	10	10	2	2
Madras				
Nicotiana rustica	—	—	—	—
Nicotiana tabacum	49	48	29	28
TOTAL	49	48	29	28
Stalks and Stems	—	—	2	2
Maharashtra				
Nicotiana rustica	(a)	(a)	(b)	(b)
Nicotiana tabacum	62	65	15	12
TOTAL	62†	65†	15†*	12†*

(1)	(2)	(3)	(4)	(5)
Mysore				
Nicotiana rustica	10	10	3	3
Nicotiana tabacum				
(*i*) Virginia	8	8	5	5
(*ii*) Others	76	79	15	16
TOTAL	94	97	23	24
Orissa				
Nicotiana tabacum	18	18	9	9
Punjab				
Nicotiana rustica	(a)	1	(b)	(b)
Nicotiana tabacum				
(*i*) Virginia	—	—	—	—
(*ii*) Others	4	3	1	1
TOTAL	4	4	1	1
Stalks and Stems	—	—	1	1
Rajasthan				
Nicotiana tabacum	16	15	4	5
Uttar Pradesh				
Nicotiana rustica	31	37	9	12
Nicotiana tabacum	10	11	3	4
TOTAL	41	48	12	16
West Bengal				
Nicotiana rustica	25	27	8	9
Nicotiana tabacum	16	16	5	5
TOTAL	41	43	13	14
Delhi				
Nicotiana tabacum	1	1	1	1
Himachal Pradesh				
Nicotiana tabacum	2	1	(b)	(b)
Tripura				
Nicotiana rustica	1	1	(b)	(b)
Nicotiana tabacum	1	1	(b)	(b)
TOTAL	2	2	(b)	(b)
Total India				
Nicotiana rustica	90	97	29	32
Nicotiana tabacum	935	892	310	275
TOTAL	1,025	989	339	307
Stalks and Stems	—	—	126	114

(a) Below 500 acres.

(b) Below 500 tons.

*Production estimates in respect of Mehsana, Ahmedabad, Kaira, Panch Mahals, Baroda and Broach in Gujarat and Satara, Sangli and Kolhapur in Maharashtra are based on the results of crop cutting surveys.

@1960-61 data repeated.

†Break-up estimated.

NOTE:—Tobacco is not grown in N.E.F.A., Nagaland, Manipur, Andaman & Nicobar and Laccadive, Minicoy and Amindivi Islands to any appreciable extent.

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IV. BAGASSE

Sugarcane is crushed in a set of multiple mills in a sugar factory to extract as much juice as possible. After the juice has been extracted, the fibrous material coming out of the last mill is known as 'bagasse'. This still contains a small quantity of sugar which cannot be economically extracted.

The composition of bagasse depends upon a number of factors, *viz.* (a) variety of sugarcane, (b) degree of cane preparation by knives etc. before milling, (c) efficiency of the milling plant and (d) degree and efficiency of imbibition (soaking of crushed cane in water to squeeze out the maximum amount of sugar in the next mill). Whereas the cane variety influences the quality and quantity of fibre, the other factors influence the moisture and sugar contents of bagasse. The main constituents and their average proportion in Indian bagasse as it comes out of the milling plant are given below :

TABLE 1

Average composition of Indian bagasse

Constituent	Percentage
Fibre	48·5
Water	48·0
Sugar	3·0
Minor constituents	0·5
TOTAL	100·0

Production of bagasse.—The fibre content of sugarcane grown in different parts of India and during different periods of the season varies from about 11.5 to 18.5 per cent on cane and the yield of bagasse varies from 23 to 34 per cent on cane. The production of bagasse in sugar factories during 1955-56 to 1959-60 was as follows :—

TABLE 2

Production of bagasse in sugar factories

Season	Sugarcane crushed (million tons)	Bagasse (million tons)	Bagasse (per cent cane)
1955-56	18·85	6·28	33·3
1956-57	20·79	6·94	33·4
1957-58	19·75	6·52	33·0
1958-59	19·49	6·22	31·9
1959-60	24·40	7·91	32·4

It will be seen from the above table that the all-India average production of bagasse is about 33 per cent on cane. The 1960-61 production of bagasse has not so far been compiled by the National Sugar Institute, Kanpur, but it can be deduced from the total cane crushed in that year *viz.* 30.6 million tons, by using the average figure of bagasse yield during the preceding five years *viz.* 33 per cent. The production of bagasse in 1960-61 thus works out to about 10 million tons.

The production target for sugar in the Third Five Year Plan is 3.5 million tons which would require about 35 million tons of sugarcane to be crushed. This would result in the simultaneous production of 11-12 million tons of moist bagasse or about 6 million tons of bone-dry bagasse.

Utilisation of bagasse.—The bagasse produced in India is, at present, almost entirely used as fuel in the boilers of sugar factories for the production of steam for generating power and for processing juice. It is used in boilers because it is a readily available fuel. It is fed into the boilers directly as it comes out of the milling plant even though its moisture content is about 48 per cent. The boiler furnaces are specially designed to burn this moist fuel. The gross calorific value of bagasse with 48 per cent moisture is 4,260 B.T.U. per lb. as against 12,000 B.T.U. per lb. for coal of good grade. The high ash content coals give about 9,500 B.T.U. per lb. Bone-dry bagasse is thus slightly inferior in calorific value to high ash coals.

Most of the sugar factories in India are not self-sufficient in bagasse in so far as their fuel requirements are concerned. They have to use extra fuel such as firewood, coal or furnace oil. The quantities of extra fuel consumed by sugar factories in 1959-60 were as follows :—

TABLE 3

Extra fuel (in addition to bagasse) consumed by sugar factories in 1959-60

Fuel	Quantity (tons)
Firewood	202,030
Coal	106,560
Furnace Oil	26,170

Some efficient sugar factories, however, not only do not use any extra fuel but save some bagasse at the end of the season. But such factories are few and the quantity of bagasse saved by them is not much. Some of this saved bagasse is sold to paper factories for producing paper or boards and some is sold to neighbouring factories requiring extra fuel. But most of it is used by the factories themselves in the off-season and in the early part of the next season when the bagasse content of cane is low. The quantity of bagasse saved during 1957-58 season was

282,830 tons, of which 20,260 tons were sold to paper and board factories at a value of about Rs. 6.2 lakhs. The quantity of bagasse saved works out to about 4.3 per cent of the total quantity produced and the quantity sold to paper and board factories forms a very small proportion.

Use of bagasse for production of paper.—Bagasse as a raw material for paper manufacture has attracted the attention of technologists for several years. In fact, commercial attempts to produce paper from bagasse were made quite early. These attempts were however, unsuccessful except for the production of low quality paper or boards. The main reason for the failure was that bagasse was used without the removal of pith. Research carried out in foreign countries indicated that for making quality paper from bagasse, removal of pith was essential. Successful working of commercial ventures became possible only after this fact was realised.

Dry bagasse consists essentially of fibre and pith. The fibre con tent is about 65 per cent of dry weight and the pith including soluble matter constitutes the remaining 35 per cent. The fibres are suitable for the manufacture of paper of good quality. The pith, on the other hand, has no value as a paper-making material and pulping of bagasse containing pith leads to larger consumption of chemicals used for digestion, difficulties in washing and bleaching the pulp, slow rate of draining of the stock on the paper machine and less opacity of the resulting paper.

It is, therefore, necessary to separate the pith from fibre for the manufacture of paper. The separation of pith should be undertaken in the sugar factories in order to reduce the baling, storage and transport charges on bagasse meant for paper production. The pith may be used as fuel in the sugar factory.

The physical and chemical characteristics of bagasse as compared to bamboo and sabai grass, the main raw materials for the manufacture of paper and pulp in India, are as follows :

TABLE 4

Physical and chemical characteristics of bagasse, bamboo and sabai grass

	Average fibre length in mm.	Average fibre diameter in microns	Ash (percent)	Lignin (per cent)	Cellulose (percent)	Pentosans (percent)
Bagasse (depithed)	1·4	18	1-2	18-20	54-58	24-26
Bamboo	2·5—4·0	14	1-3	15-32	56-57	15-32
Sabai grass	2·1	9	6	22	54-55	23-24

With the expected rise in tempo of development during the Third and subsequent Plan periods, the demand for paper and paper products is bound to increase to meet the growing demand for mass literacy, the packing requirements of industry and for several other uses. The production target for paper and paper boards in the Third Five Year Plan, *viz*. 700,000 tons, is more than double of the achievement at the end of the Second Plan. The newsprint target in the Third Plan is more than five times the indigenous production in 1960-61. An annual production of 100,000 tons of chemical pulp is envisaged for the first time in the country during the Third Plan period. For achieving these targets, the supply of suitable fibrous raw materials is a major problem of the paper industry.

It is feared that in the not too distant future the country may be faced with shortage of bamboo and sabai grass. The Raw Materials Panel of the Development Council for Paper, Pulp and Allied Industries has anticipated a crisis after about five years unless more effective steps are taken to augment the present resources of cellulosic raw materials. The existing resources in the country could provide at the most two million tons of bamboo per annum. Another million tons of other fibrous materials like grasses, straws, jute sticks, linseed stalks, waste paper, rags etc. might be available. The raw material requirements for the Third Plan targets for paper, boards, newsprint and chemical pulp have been estimated at 2.4 million tons. The targets visualised for the Fourth Plan would require about 4.0 million tons of fibrous materials. This means that one million tons of dry bagasse would have to be made available to the paper and allied industries for fulfilling the Fourth Plan targets. The requirement of bagasse may go up to the extent there is a shortfall in the supply of bamboo, sabai grass and miscellaneous raw materials.

The resources of soft woods, which are the conventional raw materials for the manufacture of pulp and paper in the industrially advanced countries, are restricted to the higher reaches of the lower Himalayan regions. The problems connected with the extraction and transport of timber from high mountain forests and their regeneration by natural and artificial means have not been satisfactorily solved so far. Recently, some steps have been taken to study the feasibility of the utilisation of such timbers available in Punjab, Himachal pradesh and Jammu and Kashmir for manufacture of suitable types of pulp and paper, with the assistance of experts from Canada and U.S.S.R. A newsprint factory has been licensed for establishment in Kangra District (Punjab) which would use Himalayan conifers as raw material. M/s. Abitibi Power and Paper Co. Ltd. of Canada are the technical consultants for this project. Of course, care will have to be taken to replant the forests so that regular supplies are ensured in the future.

Rohtas Industries Ltd., Dalmianagar (Bihar) gave a lead in the utilisation of bagasse for paper manufacture by installing a 20 tons per day pulping plant in 1950. Shri Gopal Paper Mills, Yamunanagar (Punjab) have also installed a 30 tons bagasse pulping plant. Both of these firms are using bagasse pulp in admixture with long-fibred pulp from bamboo or sabai grass for the manufacture of paper.

Bagasse pulping received impetus during the last few years when licences were issued under the Industries Act for the establishment of paper and newsprint mills based on bagasse. The names of the schemes, their location, capacities and requirements of bagasse are given in the Appendix. The total requirement of bagasse for these schemes works out to about 1.1 million tons.

Of the licensed schemes, Mandya Paper Mills and Seshasayee Paper and Boards have already started production. It is understood that Mandya Mills, which is the first paper factory in the country designed to use 100 per cent bagasse in the production of quality paper, have run into some difficulties. They need 20-30 per cent of long-fibred pulp to mix with bagasse pulp to produce good quality of paper. This long-fibred pulp has to be imported which is extremely difficult in the present foreign exchange situation. This is so because all the existing paper mills in the country are composite units which manufacture pulp to meet their own requirements. Contrary to practice in other countries where large pulp mills are located near the sources of raw materials which feed the paper mills located near consuming centres, there is no factory in India which produces pulp only.

Seshasayee Mills are using only 35 per cent bagasse pulp for their paper production, the rest being bamboo pulp. Ashok Paper Mills in Bihar are expected to start production shortly. They would use about 60 per cent bagasse in admixture with bamboo and sabai grass. Other schemes have made very little progress. The main obstacle in most cases seems to be the uncertainty about the availability of sufficient bagasse from sugar mills. The experience of Mandya Paper Mills that they have not been able to use 100 per cent bagasse pulp for the production of quality paper has also dampened the prospects of projects licensed primarily on the use of bagasse as raw material.

How bagasse can be made available for paper manufacture.— There are two ways in which bagasse can be released from sugar factories for paper manufacture :

(a) Supply alternative fuel in the form of wood, coal or furnace oil to sugar factories and get the entire bagasse for the paper industry;

(b) Make sugar factories more efficient in respect of fuel consumption and save bagasse for paper manufacture.

In regard to proposition (a), some difficulties have been expressed by the sugar industry. These are :—

(i) The existing boiler furnaces of sugar factories, which are suitable primarily for burning bagasse, will have to be altered to suit the use of coal or furnace oil. Wood is in short supply and may, therefore, be considered to be out of question. Furnace oil is also in short supply from indigenous sources and has, therefore, to be imported. It would be more economical to use furnace oil near the refineries or the port towns situated away from the collieries. Although fuel oil is costlier than coal, it has some important advantages such as better control over combustion and consequent better efficiency of fuel utilisation.

The alteration would cost Rs. 8-9 lakhs in a sugar factory of 1,000-1,500 tons per day cane crushing capacity for conversion to coal and Rs. 3-5 lakhs for conversion to furnace oil.

(ii) The sugar industry has expressed serious doubts whether regular supplies of coal or furnace oil to the sugar factories can be arranged in view of the existing transport bottlenecks. A 1,000 tons factory would require about 100 tons (4-5 wagons) of high ash content coal per day, *i.e.* 15,000 tons of high ash coal per season or alternatively 50 tons of furnace oil per day *i.e.* 7,500 tons of furnace oil per season. In addition to involving considerable transport capacity, this would require large yard space for stocking coal or storage tank capacity for furnace oil. Good quality coals are required for more deserving industries *e.g.* cement, glass etc. and, therefore, may not be available to sugar factories.

(iii) Equipment for depithing and baling of bagasse and storage space for baled bagasse would be required which would involve additional investment.

(iv) Transport would again be required for carrying bagasse from sugar factories to paper factories.

The sugar factories are, therefore, reluctant to change their boiler furnaces to operate on coal or furnace oil and thus release bagasse for the paper industry. These aspects have been discussed in the Development Council for Paper and Allied Industries and in the Ministries of Commerce and Industry (Development Wing) and Food and Agriculture (Directorate of Sugar and Vanaspati). There is very little which the Government can do to allay the fears of the sugar industry in respect of coal or furnace oil supplies besides giving an assurance that the fuel requirements of the sugar industry would be met on a priority basis. But that may not be enough for a continuous process seasonal industry. If a sugar factory has to close down even for a few days for want of fuel supplies, it will not only affect the working results of the industry but thousands of cane growers in the area will be seriously affected. On the other hand, the seasonal character of the sugar industry is advantageous in that buffer stocks of coal or furnace oil can be built up during the off-season. This would no doubt lock up some working capital but it should not be grudged as the use of bagasse for paper manufacture will be more appropriate and in the national interest due to the apprehended shortage of cellulosic raw materials for the paper industry. Furthermore, the supply of coal to industries is expected to improve with the introduction of the revised pattern of distribution. Under the new pattern it is envisaged that movement of coal to consumers, whose monthly requirements are 1,500 tons or more, will be in block rakes whereas consumers, whose requirements are below 1,500 tons per month, will draw their supplies from dumps which will be created at selected centres and supplied with coal in block rakes from the collieries. The question of raising finance for the sugar industry for conversion of boiler furnaces, depithing and baling arrangements and storage of bagasse will also have to be tackled.

The cost of bagasse for paper manufacture would depend mainly on the cost of alternative fuel of equivalent thermal value and some definite workable arrangement for supply of alternative fuel to sugar factories in exchange for bagasse will have to be made. Recently, some arrangements have been mutually agreed to between the sugar mills and the promoters of paper projects intending to use bagasse as raw material. Government has come in only by way of encouraging such arrangements and assisting the licencees to implement their projects. Some of these arrangements have been made on no-profit no-loss basis. The paper factories have supplied oil-fired boilers and the necessary fuel to the sugar mills and in turn taken away all the bagasse produced in the sugar mills. Mandya Paper Mills and Seshasayee Paper Mills are examples where such arrangements have been made. Because both the sugar and paper industries are mostly in the private sector, it is felt that this pattern may continue and be actively encouraged by the Government until a substantial portion of bagasse produced in the country is utilised for paper production. A Bagasse-for-Paper Promotion Committee, consisting of the representatives of the Ministry of Food & Agriculture (Directorate of Sugar and Vanaspati), the Department of Technical Development (former Development Wing) of the Ministry of Economic and Defence Coordination and the Planning Commission and the Director, National Sugar Institute, Kanpur may be constituted which may get in touch with the licencees of bagasse-based paper projects and assist them in bringing their projects into production speedily. If necessary, an expert from the Forest Research Institute, Dehra Dun, may be co-opted as a member.

To begin with, perhaps all the boilers in sugar factories may not be altered for operation on coal or furnace oil. Only half of them may be changed and the bagasse thus released used for paper manufacture. To this may be added the bagasse saved by improvement in fuel efficiency of the sugar factories which is discussed in the succeeding paragraphs. Sugar factories located near the collieries or refineries may change all their boiler furnaces to coal or oil.

As regards the second alternative, *viz.* saving bagasse by improving the fuel efficiency in sugar factories, it has been stated earlier that only about 280,000 tons of bagasse were saved in 1957-58 out of the total production of about 6.5 million tons in that year, which is a small proportion. It is, however, possible to effect substantial economy in the use of bagasse as fuel and quite a large quantity of it can be saved if the necessary fuel and steam economy measures are adopted by sugar factories. In the opinion of the National Sugar Institute, Kanpur the fuel requirements of sugar factories can be met from about 28 per cent of bagasse on cane. Those factories whose bagasse production is higher than 28 per cent can, therefore, save bagasse by an amount by which their production exceeds 28 per cent.

The scope of saving bagasse in the regions where its production is higher than 28 per cent is as follows :—

TABLE 5

Scope of saving bagasse on the basis of consuming 28 per cent on cane as fuel

Region	Bagasse (percent cane)	Estimated saving of bagasse (tons)
Punjab	32·3	47,500
West U.P.	33·3	326,500
Central U.P.	35·6	194,200
East U.P.	35·1	304,200
Bihar	36·3	285,100
West Bengal	33·4	5,100
Orissa	29·2	400
Madras	29·6	15,000
Madhya Pradesh	32·1	11,800
Rajasthan	30·2	3,100
TOTAL		1,192,900

Minimisation of fuel consumption in sugar factories most of which (particularly in North India) are 25-30 years old is, however, not an easy task. Equipment design, manufacturing technique and product quality have made rapid advances during the last couple of decades. Besides effecting modernisation to enable continuous processing at various stations in place of batch methods now in vogue in most of the sugar factories, it will be necessary to adopt the following measures :

(a) Reduction of moisture in bagasse by improving the milling operation;

(b) Installation of high pressure boilers with water walls, super-heaters and adequate heat recovery units like economisers and air preheaters;

(c) Improvement of furnace design with forced and induced draughts ensuring maximum combustion efficiency;

(d) Adoption of steam economy measures such as recovery of heat from vapours for initial heating of juice, utilisation of condensates for raising the temperature of feed water for boilers, insulation of hot surfaces, etc.;

(e) Installation of efficient turbo-alternators using high pressure steam and semi-electrification of prime movers (changing wherever possible from steam to electric drive); and

(f) Instrumentation and automatic operation ensuring steady conditions of working.

In order to effect the above changes it is necessary to carry out expert surveys, prepare blue prints and carry out the recommendations in a planned and phased manner. Considerable amount of finance would be necessary with an appreciable amount of foreign exchange complement. Though a major part of the sugar mill machinery is now manufactured in India, most of the items required for modernisation are not yet produced here. When these measures are adopted, not only will a substantial amount of bagasse be saved for the paper industry, large quantities of wood, coal and furnace oil would be saved which are at present used as extra fuel. It is estimated that besides about 1.2 million tons of fresh bagasse, 190,000 tons of wood, 100,000 tons of coal and 10,800 tons of furnace oil will be saved which would be a national gain.

The National Sugar Institute has been actively engaged in investigating the causes of excessive fuel and steam consumption in sugar factories and in giving the necessary advice to improve their efficiency. At the instance of the Development Council for Sugar Industry an extension service scheme was started by the Institute in 1957. So far, preliminary survey of 23 factories and final survey of 12 factories have been completed. In the case of the latter 12 factories, recommendations have been made for achieving the possible efficiencies. However, these recommendations have not been implemented in most cases because either the factories have not been able to spare the necessary funds required for effecting major changes in boiler and processing equipment or difficulties have been experienced in procuring the necessary machinery from abroad.

The extension service facilities provided by the National Sugar Institute should be augmented so that a larger number of factories can be taken up for survey than at present. There are now about 180 working sugar factories in the country. The target date for the Sugar Institute to complete the survey work should not be later than the end of the Third Plan period so that the renovation and modernisation programmes in the sugar factories can be implemented during the Fourth Plan period, preferably the first half of it.

As recommended by the Achievement Audit Committee (Thacker Committee) which recently examined the question of developing the National Sugar Institute to meet the requirements of the industry, the following off-season courses should be started in the Institute for the benefit of technicians working in the industry :—

(a) Certificate course in mill and boiler operation and control,

(b) Certificate course in manufacturing operations and control, and

(c) Instrumentation and automation.

Trained technicians will be helpful in reducing the fuel and steam consumption in the sugar factories.

The Tariff Commission had recommended in their Report (1959) on the cost structure of sugar and fair price payable to the sugar industry that Government should arrange financial assistance to the sugar factories as had been done for cotton and jute textile industries for renovation and modernisation of their plant and equipment. The recommendation is still under consideration of the Government. In order to save bagasse for the paper industry, this recommendation deserves implementation forthwith. Government should also release foreign exchange for importing the plant and equipment which are not yet manufactured in the country or are manufactured in insufficient quantities.

It has sometimes been suggested that bagasse produced in khandsari and *gur* units should be utilised for the production of paper. These units are so widely scattered that the collection of bagasse in sizeable quantities even in concentrated areas would be very costly. Moreover, as bagasse is used as fuel in these units also, it would be necessary to substitute coal or firewood in its place and this would present practical difficulties.

APPENDIX

Bagasse-based paper mill projects licensed under the Industries Act.

Serial No.	Name of the licencee	Location	Annual capacity (tons)	Requirement of bagasse (tons)
New Units				
1.	Mandya National Paper Mills Ltd.	Balagola (Mysore)	21,600	108,000
2.	Ugar Sugar Works Ltd. ..	Athani (Mysore)	9,360	30,000
3.	Ashok Paper Mills	Darbhanga (Bihar)	15,000	26,000
4.	Seshasayee Paper and Boards Ltd.	Cauvery (Madras)	20,000	20,000
5.	Northern India Paper Mills ..	Meerut (U.P.)	27,000	42,000
6.	Uttar Pradesh Pulp and Paper Mills	Jansath (U.P.)	21,000	50,000
7.	Somani Pulp and Paper Mills	Gorakhpur (U.P.)	15,000	40,000
8.	Delhi Cloth and General Mills Ltd.	Daurala (U.P.)	36,000	90,000
9.	Hindustan Sugar Mills Ltd. ..	Golagokarannath (U.P.)	15,000	60,000
10.	Bedi and Co. (Private) Ltd. ..	Panipat (Punjab)	30,000	170,000
11.	Shri Sohan Lal	Rahuri (Maharashtra)	42,000	100,000
12.	K. L. Gupta and Co. ..	Nasik (Maharashtra)	37,200	112,000
13.	Rohtas Industries Ltd. ..	Karad (Maharashtra)	60,000 (newsprint)	90,000
14.	Birla Gwalior (Private) Ltd. ..	Moradabad (U.P.)	30,000 (newsprint)	45,000
Substantial Expansions				
15.	Bengal Paper Mills Co. Ltd. ..	Raniganj (W. Bengal)	37,500	90,000
16.	Rohtas Industries Ltd. ..	Dalmianagar (Bihar)	11,400	10,000

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V. ECONOMIC RESOURCES OF MARINE ALGAE

One of the earliest uses of seaweeds in the West was in agriculture as fodder and manure. In Malaya, parts of the Pacific Coasts of the U.S.A., the Dutch East Indies, Burma, Siam, Borneo, Hawaii, Indo-China, Japan and China, seaweeds are used as food. In England and Scotland Rhodymenia is used as an appetiser, fresh or cooked, and served like spinach. Japan is foremost in utilisation of seaweeds, and seaweed industry is well established there. Seaweeds are very rich in proteins, fats and vitamins and form one of the cheapest source of nutritive food.

Seaweeds of economic importance are available all along the Indian coast. In fact, it may even be possible to set up 'seaweed farms' along our coasts to cultivate these plants.

Indian resources in seaweeds are sufficiently valuable to justify utilisation. The most abundant Indian seaweeds are those that yield agar and algan. The former comprise red algae of the general *Gelidium, Sarconema, Garcilaria* and *Hypnea.* The latter comprise brown algae of the genera *Sargassum, Cystophyllu, Turbinaria, Dictyota, Padina, Hormophysa, Colpomenia, Hydroclathrus* and *Rosenvingia.* Among the edible seaweeds may be mentioned the green algae *Enteromorpha, Ulva, Codium* and *Caulerpa;* and the red algae *Porphyra, Grateloupia, Acanthophora* and *Laurencia. Enteromorpha* and *Ulva* can be used in making jams and candies. The Gracilarias can be used in the manufacture of agar, and as seaweed porridge.

The available information on the economic resources indicates that agarophytes of the Chilka lake alone would amount to about 4 to 5 metric tons per annum (dried weed); of the Cape Comorin area about 1 metric ton per annum (dried weed); and of the Pamban area about 7 metric tons per annum (dried weed). In 1959, on an all-India basis, Thivy estimated the dry yield to be about 35 metric tons annually, yielding about 12 to 13 metric tons of agar. Taking into account the retail price of agar, Thivy has put the value to be about Rs. 4.5 lakhs.

There is at present no precise information on the quantity of alginate weeds available in our waters. From the preliminary survey conducted by Department of Agriculture, it could safely be estimated that about 100 metric tons of dry weed could be collected annually, yielding about 20 metric tons of alginic acid. In addition to this, cast ashore sea-weeds form a very good source of manure amounting about 10,000 metric tons (wet weight) annually. At the rate of 10 metric tons per acre these would be sufficient to enrich 1,000 acress of cultivable land.

The majority of the economic seaweeds are found within the intertidal zone on coral or sandy-rock formation along the Indian coast. Coastwise information about the type of seaweeds found is given below.

Harvestable quantities are found in the following areas; (i) Gujarat coast consisting of Okha, Dwarka, Porbandar and Varaval. In this area, the more important weeds are *Gelidium, Sargassum, Colpomenia, Entermorpha* and *Ulva.* (ii) Bombay coast consisting of Bombay, Ratnagiri and Melwan, has an abundance of brown algae like *Sargassum, Cystophyllum, Padina* and *Dictyota;* and green algae like *Ulva, Enteromorpha* and *Caulerpa.* (iii) Karnatak coast in Karwar, yields *Sargassum* and *Enteromorpha.* (iv) Kerala coast in Vizhingan, Kovalam and Poovar, has a good supply of *Gracilaria, Hypnea, Sarconema, Ulva, Caulerpa; Sargassum, Cystophyllum,* and *Dictyota.* (v) Madras coast consisting of Cape Comorin, Tirichendur, Tuticorin, Mandamam and Pamban group of islands and Madras (Adayar and Mahabalipuram) is the richest zone from the point of economic algae. (vi) Orissa coast consisting of Chilka lake has a dominance of *Gracilaria.* (vii) The Andaman Islands and the Laccadives are considered to be a very productive area also.

Uses :

Agar is a jelling substance which dissolves in boiling water and the solution sets to a jelly at room temperature. For jelling agar, no special cooling method like the application of ice or use of freezing chamber is generally required. Once it becomes a jelly, agar retains that property for a very long time irrespective of change in temperature. In the jelly condition, every gram will have about 10 grams of water in an imbedded state. This property of agar, coupled with the high clarity of the jelly makes it an ideal medium for the culture of micro-organisms for laboratory and industrial purposes, manufacture of anti-biotic organisms, etc. Agar is very largely used in leather, paper, photographic film and plate, tungsten wire, dental-impression material, surgical dressing, confection sweets, jams, vegetable paste, canned fish, cosmetics, toothpaste and other allied industries.

Alginic acid is a gelatinous substance which practically does not dissolve in water, cold or boiling, and goes into solution only when treated with an alkali. The water-soluble alginates can be made into insoluble salts by treatment with alkali earth or heavy metals. The common industrial alginates are those of sodium, ammonium, calcium, aluminium and copper. Sodium alginate to which the name algin is usually applied is used in the manufacture of cheese, milk-powder, custard-powder, cakes, jams, jelly-sweets, aerated waters and fruit drinks. In stabilising ice-cream it is employed more commonly than agar. It is used in milk puddings where the calcium of the milk forms gelatinous calcium alginate. The addition of sodium alginate in pharmaceutical and cosmetic preparations is common. It is also used in textile industry, paints and varnish industry and in water-proofing wood, textile and paper.

Because of the high content of minerals, trace elements and vitamins, seaweeds serve to supplement the usual rations of farm animals. Seaweed meals are a new feature in stock raising in many countries. In addition, some like *Halimeda, Corallina* and *Jania* could be dried and given alongwith the normal rations to poultry as they are rich in calcium.

Seaweeds serve a very useful purpose as manure. They can be used after drying or as compost. They are particularly good for sandy tracts where there is fast drainage of moisture and consequent drying of the root system of plants. By the addition of seaweeds, in these situations, apart from giving nutrients to the plants, the rhizosphere is kept moist throughout due to the water imbibing property of the seaweeds. The results of experiments, conducted with "sea-magic" (trade name of the product derived from seaweeds) to determine the manurial value of these weeds, on wheat and berseem at the Indian Agricultural Research Institute show that the yield of berseem does show a marked increase.

General considerations :

Under the Five Year Plan Programme, attention was given to the utilisation and survey of marine resources—seaweeds—with detailed investigations on taxonomy, survey, biology, harvesting, culture and means of utilisation, in order to aid in the development of seaweed industry in India. The above studies would aid in setting up of a cottage industry for the manufacture of agar, household agar, etc., and in the utilisation of seaweeds rich in minerals and vitamins as human food.

Apart from the above aspects, seaweeds are also prominent elements in the ecology of inshore environments and a critical study of these plants is essential for a complete understanding of the 'biota' of the inshore waters of India.

Even in a country like Japan, where seaweeds are available in large quantities and are even cultivated to meet the local demand, more than 2,000 tons of dried raw material is imported annually to meet the requirements of the industries. In our country too, in starting agar and algin industries, possibility of import of raw material cannot be overlooked, because, the raw material locally available will not be sufficient to sustain the industry on a sound basis.

Transportation of seaweeds is one of the major hurdles in establishing seaweed industry. Seaweeds generally contain about 65 to 85 per cent of water in wet condition, and sun drying for about 5 to 7 days easily reduces this to about 25 to 30 per cent. In such a state, the weeds could be stored in ventilated places and transported in gunny bags.

Secondly, large quantities of fresh water, are required for washing before processing. This restricts the choice of setting up "sea-weeds" industry along the coastline.

The seaweeds at the moment are collected on sea shore in between the tides. There is no organised collection of weeds. It needs to be studied in all details, whether the collection should be mechanised as in the case of Japan, or the fishing boats should be used. The economics of collection also require to be worked out.

VI. BY-PRODUCTS OF FRUITS AND VEGETABLE PROCESSING INDUSTRY

The fruit processing industries in India are concerned with the processing of fruits and a small quantity of vegetables. Among the fruits utilised are mainly the mango—unripe green mango for chutney, ripe mangoes for canning and for the purpose of processing mango beverages, like mangola etc; citrus fruits—mainly mandarin oranges for juice and segments; small quantity of lemons like *galgal* etc. and limes for the preparation of lemon squashes, candy, cordial etc.; pine-apple for canning slices and juice; apple for juice murabbas and jam; guava—for guava jelly. In addition to these products of different fruits, small quantities of appricots, plums and strawberry are used for making jams. Papaya although a common fruit is not utilised to any great extent for purpose of preservation by the fruit processing industries. There is a small scale production of papain from fruits. After extraction of papain, the fruits may be used for processing and for pectin manufacture. As regards cashewnut, by-products from the cashew-apple and the shell can be of great use for different products.

With the production of different items of preserves by the fruit processing industries, the availability of the different fruits and production of suitable varieties are correlated. Among the fruits grown in India more than 70 per cent of the total area is under one fruit *i.e.* mango, the production of which is concentrated mainly in Punjab, Uttar Pradesh, Bihar, West Bengal, Maharashtra, Gujarat and Andhra Pradesh. Other fruits of importance in order of acreage are the citrus fruits (mandarin, sweet oranges, lime), banana, papaya (exact area not known), guava, pineapple, apple and jackfruit. Among the citrus fruits, mandarin oranges are located in three important zones—(1) Central India, (2) Eastern India (Assam, West Bengal, Sikkim and Tripura), and (3) Mysore, and occupy larger area than the sweet oranges which have also three main centres (1) Punjab and Rajasthan (Malta type), (2) Andhra (Sathgudi), (3) Maharashtra (Mosambi). Among the limes and lemons, the major area is under acid lime located in Andhra. True lemons are little cultivated in India. In north India, lemon squash manufacturers generally use the juice of the rough lemon, *galgal*. At present mandarin oranges are processed for juice to a great extent in Central India, as the production of sweet oranges is not in great quantity. As a result of the working of fruit development scheme in Second Five Year Plan, extensive plantings of sweet oranges have been made in the Punjab, round about Abohar, and the adjoining tracts of Rajasthan in Ganganagar area. Excellent fruits are being produced in this area and in course of another few year this area would be able to produce sufficient fruits for the processing industry and also for the manufacture of better quality by-products like the orange oil, pectin, etc. Although banana occupies considerable area in South India and in Eastern India, not much of it is used by the processing industry. More of the fruit is used directly for table purposes. The stem of the banana is a good source for starch and fibre making, but collection is difficult. Pineapple is an excellent fruit for the processing industry. The present industry is comparatively small and is mainly located at Trichur in South India. It has, however, a great scope for development in Eastern India, stretching from Assam to West Bengal and Bihar if sufficient utilisation of the fruit can be made. The production of guava is concentrated more in Uttar Pradesh and the adjoining States. A small quantity of the fruit is used by the processing industry for jelly making. Cultivation of apple is being extended considerably in the Himachal Pradesh, Uttar Pradesh and Punjab Hills. A small beginning has been made in the production of apple juice and apple pulp by two factories. Jack fruits grow almost wild in Eastern India and also in Kerala. But almost no use is made of it by the processing industry. Cashewnut is produced mainly in South India and a number of factories are located in Kerala for shelling cashew kernel from the nuts which are exported. The by-products which are available with these factories can be utilised by the Industry.

Utilisation of fruit wastes from the processing industry :

As indicated previously the major items of waste from the fruit processing industry are as follows :—

Fruit	Waste	Location
Mango	Peel and stone	Maharashtra (Bombay), West Bengal (Calcutta).
Mandarin orange ..	Peel, rag, pomace	Nagpur, Eastern India (Sikkim Tripura, Gauhati).
Sweet orange	Peel, rag, pomace (small quantity)	Punjab, Kodur (Andhra Pradesh).
Lime	Peel, rag, pomace (small quantity).	Kodur (Andhra Pradesh).
Pine apple	Peel, pomace, crown and stem.	South India (Trichur), Eastern India (Siliguri, Gauhati, Tripura and Calcutta).
Guava	Skin and pomace.	Calcutta and U.P.
Apple and deciduous fruits.	Skin, pomace, core.	U.P. (Ramgarh), H.P. (Solan), Delhi (Morabba Industry).
Cashewnut	Shell and cashew apple	Kerala.

It will be seen from above that major items of by-products are from citrus fruit wastes like the peel, pomace, etc. There is possibility of utilising this for extraction of oil and pectin. Along with the production of oil from peels of mandarin oranges, it will be necessary to undertake research on the enrichment of this oil in its quality. Researches on the quality of oil from peels of limes and lemons like *galgal,* which is used in northern India for squash manufacture, may be taken up. As pectin is now imported, its production will help in reducing imports. Along with the production of pectin from citrus waste, researches may be taken up for utilisation and extraction of pectin from papaya, guava waste and the apple pomace.

The pomace left after extraction of juice from pineapple may be utilised for manufacture of a good quality vinegar by the process evolved at the Central Food Technological Research Institute. Bromelin may be manufactured from pineapple waste but its economics require further investigation.

As regards mango, its peel and stone can be collected only from the centres of processing industry for commercial utilisation, although these are available in large quantities in the concentrated zones of production of mango. There is also much wastage of seedling mango fruit in Uttar Pradesh, Punjab and other producing States. As this is an important fruit of this country and very little investigation has been made on utilisation of its products etc. this requires intensive attention. Process for the manufacture of starch from the mango seeds have been evolved, but the question of availability of the stones as by-products from the factories undertaking preparation of mango squash, beverages and canned mango slices and pulp should be investigated.

As regards apple products, the Central Food Technological Research Institute has already made some investigations on the preparation of cider, pectin, etc. But further research is necessary for its utilisation as in course of a few years there will be higher production due to extensive planting undertaken in the hills as a result of the fruit development schemes in the Second and Third Five Year Plans.

The total production of raw cashewnut is about 70,000 tons and about 120,000 tons of raw nuts are imported every year. By research on cashew apple and cashew shell, the Central Food Technological Research Institute, National Chemical Laboratory, Forest Research Institute and other organisations have developed a number of items of manufacture from the by-products. The economic possibility of utilising them for manufacture on a commercial scale requires investigation.

Among the vegetables, the items of major importance are the tomato for juice, ketchup, etc., and the pea for canning and dehydration. Systematic studies for utilising their by-products and also waste from carrot, cauliflower, etc. should be undertaken, as in course of time these products will be processed in more quantities.

There is a possibility of utilising citrus and pineapple wastes also as cattle feed, as is being in the United States of America. But the economics and acceptability of this product as cattle feed from these and the mango stones require further investigation.

VII. LAC WASTES

India is one of the two countries producing lac in the world. The annual production in the country (which constitutes 70—80 per cent of the world output) varies widely (*vide* Appendix 'A'). Average for the last ten years is about 41,300 tonnes (11,00,000 maunds).

Practically the entire output of sticklac in the country is processed into seedlac, part of which (40—45 per cent) is exported as such and the remainder further refind into shellac, buttonlac and dewaxed and decolourised lac before export (*vide* Appendix 'B'). The consumption of lac within the country (Appendix Table 3) is estimated at only 8 per cent of the total production.

Sticklac, which is the crude material harvested from the host trees and separated from the twigs, is first subjected, after coarse crushing, to a process of washing with water. This removes the water soluble dye and dead insect debris, bark, twigs and other extraneous impurities. The resulting product is seedlac which is further refined by a process of hot filtration into shellac or button lac, or by solvent methods into dewaxed and decolourised lac.

Waste products (by-products) of lac :

(a) *Scraped twigs.*—The first by-product are the twigs left over after scraping off the lac encrustation from the harvested branches of the hosts. The 41,000 tonnes of sticklac cultivation might have given the cultivator about 2,00,000 tonnes of these short thin twigs which he uses up as fuel. Another 2,00,000 tonnes, if not more, are collected during the running operations which also is put to similar use.

(b) *The dye.*—The next important waste product is the dye. Lac dye was one of the principal products from lac which is in great demand and in regular use for centuries. Even up to the end of the last century, it was the principal lac material of commerce and export. The chief use was for the dyeing of wool and silk on which it produced fast and attractive shades. With the turn of the century and the discovery and development of synthetic dyes, however, lac dye ceased to have any commercial value. In fact, it is today a complete waste product washed into the drain.

Early method of isolating the dye was to treat the wash water of sticklac with lime when the Calcium salt of the dye was separated and settled down along with other suspended matter. The supernatent clear waterlayer was drained off and the sludge allowed to dry in the sun and cut into cakes for sale or export. The cakes contained about 10 per cent of the dye which was regenerated for use by treatment with acid. The Indian Lac Research Institute has now developed a new method based on treatment of the wash water with sulphuric acid. The dye separates and settles down along with other suspended matter and is collected and refined by a simple process of dewaxing with

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mineral turpentine and reprecipitating from dilute borax solution into a "technical" grade containing about 70 per cent of the pure dye.

Lac dye produces fast and attractive shades on wool, silk and other animal fibres. It has recently been shown that it is also fast on nylon. But the shades are neither as brilliant as those from synthetic dyes nor or such a wide range of colours.

It has been found that the technical grade can be produced and marketed profitably at about Rs. 10 per kg. whereas synthetic dyes are within the price range of Rs. 20 to Rs. 40 per kg. Yield of technical grade is about 2.5 per cent of the sticklac used so that from the 40,000 tonnes of sticklac (produced in this country) it should be possible to produce about 1,000 tonnes of the "technical" dye if there is demand. Being non-toxic, possibilities of use of the dye for food colours were investigated but without success.

Lac Wax.—Sticklac contains, on an average, about six per cent of its weight of wax and seadlac, the yield of which is only 50—60 per cent of sticklac, only 4-5 per cent wax. A large amount of wax is thus lost in the washing process, most of which separates along with the crude dye on treatment of the wash water with very dilute mineral acid. The precipitated crude dye contains about 8—10 per cent of wax on its dry weight which is readily reclaimed by solvent extraction with n-hexane and is an easily saleable by-product. If properly organised, over 150 tons of lac wax valued at about Rs. 12 lakhs can be collected per annum.

Refuse lac.—Substantial amounts of valuable lac resin (about 20 per cent of the total production) is lost in by-products during the refining of crude lac into seed-lac and shellac by the indigenous country process. Refining of lac is now being carried out in small and medium sized factories in up country and one large mechanised factory at Calcutta. Over 85 per cent of sticklac is processed into seedlac in up country factories which also account for about 40 per cent of the country's shellac production.

Ghongi, Pathi, Kunhi and Molamma :

During the washing of sticklac into seedlac, hollow lac cells, dead insect bodies and twigs and wood ships float and are removed from the surface. These collectively are known as *ghongi* and *pathi*. Fine particles of lac resin remain suspended in the water and are collected separately. This is known as *molamma* or *kunhi*. The washed seedlac after drying is sieved to remove particles finer than 40 mesh. This is also molamma. Ghongi is crushed and rewashed to isolate the recoverable resin and so also pathi. The rest is a waste used sometimes as manure. Kunhi and molamma are again sieved to remove the very fine dust and to raise the resin content. Bolder grains with lac resin content of 70—80 per cent, are exported to be further refined in importing countries by a solvent process to produce good quality shellac. The fines are sold within the country for bangle making. Extremely fine particles and molamma of low resin content are practically unsaleable. Molamma is graded into molamma I and molamma II for trade purposes.

Seedlac fines.—Seedlac imported into the United States is purchased on the bases of 'bleached test' and particle size limits. For over one year now, no seedlac is accepted if more than 10 per cent of it passes through 30 mesh sieve and more than 5 per cent through 40 mesh. Seedlac is, therefore, carefully sieved through appropriate sieves to conform to these limits. The "fines" so collected are known as "seedlac fines" and are nowadays accumulating in substantial quantities in major lac refining centres.

Kiri and Passewa.—When seedlac is refined into shellac by the hot filtration process, the infusible matter is retained along with some lac in the cloth filter. This is *kiri* and may contain up to 60 per cent lac which is reclaimed by solvent extraction with spirit to produce what is known as 'grant' lac because of its dark colour. Part of *Kiri* produced in the country is converted by the mechanised factory into garnet lac while a good proportion is exported for conversion, it is reported, into good quality shellac. A small quantity is used for bangle making also.

After removal of *Kiri,* the cloth bag used for shellac making retains some lac sticking to it. This is recovered by boiling the bag with water. The resulting product is known as *passewa* and is almost pure lac (not less than 90 per cent). It is added to subsequent batches of seedlac for shellac making.

Yield of by-products.—The yields of the various by-products vary widely depending upon the details and techniques of processing and the grade and quality of the lac. A rough estimated average is given in Table 1.

TABLE 1

Production of bye-products (Refuse lac) in India (in tonnes)

State and District	Seedlac fines	Mola-mma I	Mola-mma II	Kiri	Passewa	Others	Total
Bihar							
Ranchi ..	87·655	53·339	4·662	22·380	5·222	—	173·258
Palamau ..	60·053	26·296	11·190	152·930	5·595	—	256·064
Singhbhum ..	59·680	15·106	9·325	5·035	1·678	30·959	121·783
Santal Parganas ..	67·140	30·959	13·428	26·483	6·714	—	144·724
Madhya Pradesh							
Bilaspur ..	268·560	123·090	48·490	—	—	—	440·140
Sundargarh ..	186·500	17·531	11·563	—	—	46·625	262·219
Raipur ..	126·820	58·747	25·177	52·220	12·682	—	275·646
Hosangabad	80·941	—	—	—	—	—	80·941
West Bengal							
Purulia ..	745·254	374·636	149·573	297·467	74·600	—	1,614·530
Bankura ..	22·380	10·247	4·476	8·765	2·238	—	48·116
Maharashtra							
Bhandera ..	280·682	130·960	56·136	111·900	27·915	—	609·653
Uttar Pradesh							
Mirzapur ..	93·250	11·190	11·190	130·550	—	186·500	432·680
TOTAL ..	2,078·915	825·11	345·210	807·730	136·704	264·084	4,457·754

Prices.—As mentioned earlier, the only two by-products that find a place in the internal and export trade are Molamma and Kiri. There is only one importing country—West Germany. Internal demand is very little. The prices therefore are largely dependant upon overseas demands. Internal prices of Kiri during the last ten years have varied between Rs. 268 to Rs. 1,902 per tonne (Rs. 10 to Rs 71 per maund) (*See* Appendix 'D'). No date are available for molamma. The Indian Lac Exporters Association had fixed minimum export prices for refuse lac which is reproduced below :—

Minimum Export price :

	Per tonne (Rs.)	Per maund (Rs.)
Kiri lac	643	24
Molamma, lac content 50%/ 60% ..	402	15
Molamma, lac content 60%/ 70% ..	589	22
Molamma, lac content 70%/ 80% ..	1,206	45

Export.—Exports of molamma and kiri collectively classified as refuse lac' (*vide* column III in Appendix 'B') have varied from 1201 tonnes to 3,000 tonnes (from 32,000 mds. to 83,000 mds.) per annum during the past ten years and have earned foreign exchange to the value of Rs. 7,73,700 to Rs. 64,24,000 (*vide* Appendix 'E').

Third Five Year Plan :

Research and Development.—In view of the importance and urgent necessity of effecting economy in the processing vests of seedlac and shellac, it was proposed to intensify research for the "Economic Utilisation of By-products and improving Manufacturing Techniques." It was also proposed to establish a "Lac Reclamation Unit" at Calcutta to reclaim lac from refuse lac brought to it by manufacturers on payment of the processing costs, the unit was also to serve as a model for those interested to copy.

Progress so far :

The above two schemes have been accepted as part of the Third Five Year Plan and are being implemented. Staff have been selected and are joining. A process on a laboratory scale has also been worked out to reclaim lac from refuse lac by extraction in aqueous medium, a process which would be considerably cheaper than the conventional spirit solvent method.

RECOMMENDATIONS FOR FURTHER DEVELOPMENT

(a) *Lac wax*.—As already mentioned, the one readily saleable by-product recoverable from the 'wastes' of lac industry is lac wax. This can be obtained in a yield of 0.5 per cent on the weight of sticklac washed. At present, the wash water along with the wax is allowed to go waste. It should be possible to organise collection of the wax containing crude dye in medium and large-scale lac refining factories without much additional equipment or cost. The necessary field demonstration staff will alone be necessary. The approximate quantities of sticklac washed in the major lac refining centres of the country and the estimated recoverable wax is indicated in Table below :—

State	Lac refining centre	Quantity of sticklac processed per annum (tonnes)	Estimated recoverable wax (tonnes)
Bihar	Ranchi	5,552	27·76
	Daltonganj	2,865	14·33
Madhya Pradesh..	Bilaspur	3,088	15·44
	Raipur	1,511	7·56
West Bengal ..	Malda	8,876	44·38
	Bahrampur..	6,124	30·62
Maharashtra ..	Gondia	4,480	22·40
	TOTAL ..	32,496	162·49

The total quantity of recoverable wax is thus over 160 tonnes, the estimated value of which is over Rs. 12.32 lakhs at the prevailing market rate of about Rs. 3.50 per lb. There is one factory in Calcutta adequately equipped, which may be induced to purchase and process the crude material collected at the major lac refining centres to start with. The factory is being contacted for preliminary trials. Ultimately, a wax recovering plant will have to be established, preferably at the Indian Lac Research Institute, to handle most of the wax containing waste collected in the region which can also serve as a model for other centres.

(b) *By-products lac* (*Refuse lac*).—The lac resin contained in the by-products *viz.* seedlac fines, molamma and kiri can be recovered by solvent extraction for which one factory in Calcutta is equipped but they are not utilising their full capacity for want of demand for the resulting material. The lac can also be reclaimed by the newly developed Institute's alkali extraction method, perhaps a little more cheaply, but here again unless the recovered lac has a ready market, any scheme for the purpose is not likely to be worth while. There are two uses claimed by the Shellac Export Promotion Council for which this recovered lac can be quite satisfactory and these are (i) a shellac coating for hessian to make it water and insect proof for use as a packaging material and (ii) a shellac composition for "tar felting" of roofs. The S.E.P.C. is being addressed in the matter.

There is no other known use for by-products lac, however, the staff appointed for the purpose, are investigating the problems.

(c) *Lac dye*.—Recovery of 160 tonnes of lac wax as described above will leave behind a bye-product of nearly 1,500 tonnes of crude lac dye. As explained on page 2, the ILRI has already evolved a simple and inexpensive method of refining this crude dye into a "technical" grade (of about 70 per cent pure dye content). Attempts to sell this dye including a survey by the Small Industries Service Institute, Bombay, for its use for the dyeing of wool, silk and nylon have not met with much success so far. Attempts were also made in the University Laboratories at Calcutta to modify the dye to extend its utility. The study has to be intensified and new avenues explored to make use of this product, even if as a very cheap raw material.

APPENDIX

A

Production of Statistic in India

Year	Tonnes	Maunds
1950-51	40,040	10,72,900
1951-52	48,385	12,96,500
1952-53	43,011	11,52,500
1953-54	24,407	6,54,000
1954-55	38,178	10,23,000
1955-56	46,575	12,48,000
1956-57	49,075	13,15,000
1957-58	42,563	11,40,500
1958-59	37,823	10,13,500
1959-60	43,253	11,59,000
Average	41,331	11,07,490

B

Export of Shellac & Seedlac

Year	Seedlac		Shellac		Other lacs	
	Tonnes	Maunds	Tonnes	Maunds	Tonnes	Maunds
1950-51.. ..	7,721	2,06,868	22,966	6,15,406	2,692	72,148
1951-52.. ..	6,329	1,69,590	24,481	7,09,571	3,088	82,763
1952-53.. ..	15,175	4,06,623	16,283	3,36,328	2,201	58,994
1953-54.. ..	10,446	2,79,291	13,858	3,71,349	2,889	77,435
1954-55.. ..	8,989	2,40,886	15,042	4,03,078	2,977	79,790
1955-56.. ..	8,745	2,34,334	16,899	4,52,815	3,071	82,302
1956-57.. ..	7,145	1,91,472	19,091	5,11,560	2,409	64,568
1957-58.. ..	10,852	2,90,803	15,432	5,13,520	1,285	34,446
1958-59.. ..	13,425	3,59,742	11,924	3,19,517	1,171	31,392
1959-60.. ..	11,528	3,08,914	14,174	3,79,800	1,298	34,798
Average ..	10,035	2,68,918	17,215	4,61,294	2,308	61,863

C

Consumption of Lac in India

(In tonnes)

Year	Seedlac	Shellac & Button lac	Stick lac	Other lac
1958-59..	114	503	64	480
1950-60..	116	483	52	422
1960-61..	210	555	72	425
Average per year	147	514	63	442

D

Price of Kiri Lac

Year	Maximum (Rs.)		Minimum (Rs.)	
	Per Tonne	Per Maund	Per Tonne	Per Maund
1951-52	938	35	670	25
1952-53	1,500	56	723	27
1953-54	1,340	50	670	25
1954-55	1,902	71	723	27
1955-56	1,500	56	804	30
1956-57	536	20	482	18
1957-58	696	26	268	10
1958-59	536	20	321	12
1959-60	696	26	268	10
1960-61	375	14	321	12

E

Value of Exports of Refuse Lac

Year	Quantity (Tonnes)	Value in rupees
1950-51	2,692	41,42,000
1951-52	3,088	55,02,000
1952-53	2,201	27,08,000
1953-54	2,889	44,01,000
1954-55	2,977	64,24,000
1955-56	3,071	58,96,000
1956-57	2,409	42,25,000
1957-58	1,285	13,55,000
1958-59	1,171	7,73,000
1959-60	1,298	11,28,000

VIII. WASTES AND BY-PRODUCTS FROM SLAUGHTER HOUSES AND DEAD ANIMALS

Introduction

There are 1,278 slaughter houses in the country and nearly 394 lakh animals are slaughtered annually. There are, however, only a few large slaughter houses where over 5,000 animals are slaughtered daily. Majority of the slaughter houses are small where less than 20 animals are slaughtered.* These slaughter houses were built decades ago and by now have outlived their utility. Not a single slaughter house is equipped with modern machinery and tools and their layout is unsuitable for hygienic production of meat and conserving other bye-products. This results in the avoidable wastage of valuable bye-products causing colossal loss to the nation.

Similarly the position regarding utilisation of the carcasses of fallen animals is far from satisfactory. While in some cases the carcasses are buried or thrown away intact, in majority of the cases hides are removed and that too improperly with the result that they fetch less price in the market. In rare cases, flesh, tallow, bones, hooves and horns are salvaged. According to an estimate the net annual loss due to the non-utilisation of the slaughter house bye-products and fallen animals is of the order of Rs. 2,904 lakh (Rs. 254 lakh** from slaughter house wastes and Rs. 2,650 lakh from dead animals). There is thus an urgent need to take suitable steps to ensure fuller utilisation of slaughter house wastes and the fallen animals both from the point of view of economy and for developing the leather and ancillary industries and meeting the requirements of pharmaceutical industry.

(i) *Slaughter House Wastes* :

The species of animals generally slaughtered for meat in India are buffaloes, sheep, goats and pigs. The slaughter of cows and calves has been banned in some of the States, *i.e.*, Rajasthan, Gujarat, Orissa, Punjab, U.P., Madhya Pradesh, Bihar, Mysore, etc., while the majority of the States there is a partial ban preventing the slaughter of useful cattle and buffaloes.

According to the data published (1959) by the Directorate of Agricultural Marketing and Inspection, the number of animals slaughtered annually is as follows :—

1. Cattle—745,358
2. Buffaloes—694,384
3. Sheep and Goats—37,331,470
4. Pigs—701,490.

*Farm Bulletin No. 4 of the Indian Council of Agricultural Research.

**Report on the Marketing of animal fats and certain other important by-products in India.

The bye-products from the slaughter houses fall into two groups, the edible and the non-edible. The edible bye-products include tallow, lard, guts, glands, tail stumps and blood. The non-edible bye-products include hides, skins, wool, hair, bones, useless meat, horns, hooves and condemned carcasses or parts thereof. These bye-products can be used for the production of various consumer goods such as stearin, oleomargarin, casings, guts, pharmaceutical products, animal and poultry feeds, fertilisers etc. Annual availability of these bye-products from various slaughter houses in the country, percentage going as waste and the total value in rupees of these wastes, and bye-products, are given below and also summarised in Table I.*

The slaughter houses and modern meat-packing plants in the Western countries make full use of all bye-products. In India, on the other hand, full and proper use of most of these products is not being made at present. Large quantities of glands are wasted due to non-availability of facilities for timely collection and preservation. Blood is largely wasted. Horns, hooves, bladder, guts etc., are also not completely collected in many slaughter houses. This is mainly due to lack of facilities for proper collection and processing of materials and lack of technical guidance at the slaughter houses.

According to the estimates (1961) made by the Directorate of Agricultural Marketing and Inspection, the existing wastage of various bye-products from slaughter houses in the country is of the following order :—

(*a*) *Guts.*—About 90—100 per cent of large intestines of cattle and buffaloes, 80 per cent of small intestines of buffaloes and 10 to 15 per cent of intestines of sheep and goats are not utilised. The total wastage is valued at Rs. 35 lakhs.

(*b*) *Oesophagus.*—60 to 70 per cent of oesophagus of cattale and buffaloes worth nearly Rs. 1.6 lakhs is simply thrown away and is wasted.

(*c*) *Bladder.*—Bladders of all animals are generally thrown away although small quantity obtained from cattle and buffaloes are exported for making meat sausages.

(*d*) *Blood.*—As no proper arrangements exist for the collection of blood, most of it goes waste. It is estimated that about 64 per cent of the blood produced in the slaughter houses is wasted. Wastage through blood alone in evaluated at Rs. 78. 6 lakhs.

(*e*) *Glands.*—Edible glands are generally sold along with meat for human consumption. Glands such as the thyroid, parathyriod and pituitary which are particularly valuable for the manufacture of glandular products for medicinal purposes are generally not put to proper use. Pancreas

*Agricultural Marketing Series 124 (Report on the Marketing of Animal Fats and certain important by-products in India).

which is a valuable gland for the manufacture of insulin is generally allowed to go waste. Ovaries obtained from all the animals and testes from cattle and buffaloes are wastes and only nominal quantities are utilized. Gland wastes are worth Rs. 5 to 6 lakhs a year.

(*f*) *Useless meat.*—The major portion worth about Rs. 35 lakh is allowed to go waste and only 40 per cent is used as animal food mostly for dogs and cats.

(*g*) *Horns and Hooves.*—About 63.5 per cent of horns from cattle, buffaloes and goats valued at about Rs. 65 lakhs are wasted. About 66 per cent of hooves from cattle, buffaloes, sheep, goats and pigs valued at about Rs. 33 lakhs are also wasted.

TABLE 1

Quantities of slaughter house wastes and by-products available quantities and value of the waste product.

S. No.	Slaughter house waste or by-products	Quantity available (mds.)	%wasted	Total value of wastes & by-products (Rs. in lakhs)	Remarks
(1)	(2)	(3)	(4)	(5)	(6)
1	Guts ..	11,97,687	90-100.; 80(a) and 10-15 (b)	35.00	(a) Large intestines of cattle and (b) Small intestines.
2	Oesophagus ..	1,06,253	60-70 cattle and baffaloes)	1.60	
3	Bladder ..	30,772	10	N.A.	Not available.
4	Blood ..	12,27,915	64	78.6	
5	Glands:				
	(i) Cattle 66,661				
	(ii) Buffaloes 93,470	9,50,965			
	(iii) Sheep & Goats 7,62,842				
	(iv) Pigs 27,992				
6	Useless meat	5,81,613	(c) 60	35.0	(c) 40% used as annual feed mostly for cats and dogs.
7	Horns ..	1,12,320			
8	Hooves ..	1,82,196	66	33.0	

The above data indicates only the overall availability of various bye-products and wastes from slaughter houses throughout the country. Data regarding the number of various species of animals slaughtered at individual slaughter houses are not available except for major slaughter houses in large cities like Bombay, Calcutta, Madras etc. Information regarding portion of various bye-products now being utilised in each of them is also wanting. In order to suggest suitable programmes for maximum utilisation of bye-products at individual slaughter houses, it would be necessary to conduct a special and detailed survey of all licenced slaughter houses in the country. This survey should also indicate the localities wherefrom sufficient quantities of bye-products could be collected for economical utilisation. It should also indicate the possibilities of exploiting the economic utilisation of such wastes in suitable areas where these bye-products could be collected from a number of small slaughter houses located in the area.

POSSIBILITIES OF UTILISATION OF VARIOUS ANIMAL BYE-PRODUCTS

(*a*) *Blood.*—Blood forms about 8 per cent of the body-weight of an animal but the actual quantity obtained after slaughter would be less. It is estimated that on an average 30 lb. of blood per buffalo, 20 lb. per cow and 1 to 2 lb. per sheep and goat could be obtained in slaughter houses. At present small quantities of blood are being collected in some slaughter houses. Blood is of considerable value and can be put to a variety of uses, *e.g.*, as feed stuff for feeding animals including poultry and as human food mixed with minced meat in sausages. Blood is also useful for medicinal and industrial purposes, such as preparation of albumen for glueing of plywood, dyeing of textiles and paper and dressing of leather before dyeing.

The greatest care should be taken to ensure that blood is not diluted with water as this means more moisture for removal, higher costs and a longer time for processing. Speed and cleanliness in collection and processing are important as any delay in processing and admixture of dirt with blood may cause the blood to decompose, a process accompanied by evil smells. It is necessary to provide proper bleeding rails in all slaughter houses so that maximum quantity of blood could be collected from the animals slaughtered without much contamination and loss. In slaughter houses handling a small number of animals, fresh blood may be collected as soon as possible and sun dried by open pan system. But in larger slaughter houses as in Calcutta, Bombay, Madras, and other large towns, it would be advantageous to provide vacuum driers for preparation of dry blood-meal. Such blood-meal would contain as much as 60 per cent to 90 per cent digestible protein. On a diet containing blood-meal as the only source of animal protein, the growth development of poultry can be maintained as also the egg yield. If the blood which is now wasted throughout India could be made into blood meal of a quality suitable for feeding livestock, millions of her protein starved animals could be more adequately fed. With proper adjustment and functioning of vacuum driers soluble blood powder can also be produced for use in textile and other industries which need albumin for their manufacturing processes.

(*b*) *Fat.*—At present the fat obtained from slaughtered animals is sold as a raw product by the butchers to private companies periodically. Through more careful collection and efficient rendering it is expected that the quality and the quantity of fat could be improved so also the quantity recovered. Animal fats are intimately mixed with tissue or cellular structure, making the raw fat a sort of fatty membrane. The raw fat must be heated in order to free it from the tissue by rupturing the cells and causing the fats to separate. Rendering refers to the extraction of fat from animal tissue by the action of heat which causes the cells to burst and the melted fat to run together in a form more or less convenient for collection.

Animal fats are glycerides of fatty acids, in other words, a combination of fatty acids and glycerol. Such glycerides are liable to be resolved into fatty acids and glycerol in the presence of moisture and lipase, specially with the aid of high temperature. So raw fats should be rendered as quickly as possible after slaughter. In case the fat is intended to be kept for more than a day, it may be chilled and preserved at low temperature under dry conditions.

Normally, fat should not contain more than 1 per cent of free fatty acids. A higher content of free fatty acids will indicate that there has been some delay in rendering the raw fat after the slaughter of the animal.

Guts.—There is a great demand for casings from a number of foreign countries. At present, only a small quantity of the intestines are utilised for the preparation of casings for export. Even these are not collected in time and properly cleaned and processed with the result that the casings are often found to contain defects such as uneven calibration and length, black nodes, grease spots etc. A considerable quantity also goes bad during the hot weather.

Intestines form the greater part of the alimentary canal of the animals. Normally an average ox has roughly 36 ft. length of large intestines and 140 ft. of small intestines. After slaughter, these are removed, cleaned, freed of fat, etc., washed with water, dried, processed and rolled into hanks of lengths extending up to 200 yards.

The guts of cattle are processed and packed mainly for export as casings to be utilised in the manufacture of sausages. Buffalo guts are not much utilised.

The guts of sheep and goat are comparatively thin and fragile and are partly utilised in the country for production of musical instrument strings, tennis and badminton racket guts, etc. The guts meant for use in rackets are salted. The bulk of guts from sheep and goat are, however, exported to Spain, Switzerland, Portugal and other countries mainly for industrial use and partly for sausage making.

In India the processing of guts into casings is mostly done by hand. In foreign countries some simple types of machinery are used for cleaning and calibrating the casings.

Glands.—Adequate arrangements do not exist at present at the slaughter houses, for the timely and proper collection of glands, their preservation and supply to pharmaceutical firms. This is due to the fact that the existing slaughter houses in the country were constructed some decades ago and hence they lack sufficient floor space and modern facilities for the hygienic slaughtering and processing of carcasses and efficient collection and utilisation of various glands.

The nature of most of the glandular products that are manufactured from them is such that the glands and organs have to be collected and processed as quickly after slaughter as possible to avoid deterioration. The butchers have to be persuaded to remove these organs from the carcasses expeditiously. Glands should never be in direct contact with water because the active principles may be partially or totally leached out. In certain cases *e.g.*, pituitary, quick freezing is essential; it is not enough to put the glands in a cooler; they must be deep frozen at a temperature not over 0° F. For freezing, the glands should be spread on trays so that, as far as possible, one does not touch another.

The question of the utilisation of glands and organs for the manufacture of glandular products was considered by a board appointed by the Council of Scientific and Industrial Research at its meeting held on 21st March, 1956. The Board considered that the production of glandular products in India from animals would be uneconomical as the facilities available for collection of glandular products in slaughter houses are primitive and the quantity of glands available was not sufficient. However, they were of the view that the economics of production had not been worked out in India. In view of the fact that the economic utilisation of these glands and organs was primarily dependent on their large scale collection, the modern slaughter houses proposed to be established in Bombay, Calcutta and Madras, should contribute to the economic production of glandular products.

Useless meat.—The inedible offals from the slaughter houses usually comprise feet, head, lungs, wind pipes, spleen, trimmings, udder, tripe, etc. Only about 40 per cent of the above is used as dog meat in the country and the remaining 60 per cent is wasted at present.

Inedible offal or condemned meat has no value at the slaughter house. The meat consumer is unwillingly bearing the cost of this inedible material. So long as stockfeed is manufactured from such free raw materials, its cost is economic, as only the cost of production is involved. Since it is rarely possible to make immediate use of condemned materials, hence the need to convert offal into meat-meal of good keeping quality. Meat-meal of good keeping quality should have a low fat and moisture content and above all a pleasant odour. To facilitate the preparation of product of such quality, it will, be however, desirable to install a commercial bye-product plant so that the method for hygienic production of meat-meal can be adopted conveniently. Besides, from the economic point of view as well, the installation of such a plant for utilization of condemned material and offal seems desirable even when the quantity of raw material available for processing may not be very large.

(ii) *Utilisation of the Waste from Dead Animals* :

On the basis of a minimum of 8 per cent annual mortality among large animals in the country, it is estimated that about 117 lakh fallen carcasses of large animals are available annually. Most of these are not being fully utilised. Usually all the hides and some of the bones from fallen animals are collected while other products such as meat, fat, horns, hoofs etc., are allowed to go waste. The hides obtained are often found defective due to faulty methods of flaying and curing practised by the traditional flayers. According to an estimate, the net annual loss due to faulty methods of flaying and collecting hides and non-utilisation of the bye-products from fallen animals is Rs. 26.50* crores.

In India, the major portion of the bones available are from fallen animals while those from slaughtered animals form only a small portion. The annual availability of raw bones has been estimated to be 3.64 lakh tons. Out of 3.64 lakh tons, 1.36 lakh tons are collected annually. The quantity that remains uncollected and thus allowed to go waste every year is approximately over 2.28 lakh tons which is more than one and a half times the quantity collected.

Bones amount to approximately 15 per cent of the weight of the dressed carcass, depending on the age and condition of the beast. In extremely fat beasts it may be only 12 per cent, while in emaciated cattle it may be as high as 30 per cent, fresh bones yield an appreciable amount of fat, which can be recovered either by boiling is open pans or under pressure.

Bones are used for several purposes:—

(*a*) for the production of stockfeed, such as meat and bone-meal when processed together with other offal.

(*b*) as steamed bone-meal, produced from defatted bones digested under pressure. The inorganic matter of bones consists of slightly more than 32 per cent calcium and a little less than one-half this amount is phosphorus. Both are invaluable supplements for feeding livestock;

(*c*) for gelatine and glue production, as ossein.

At present only a *few* big bone crushing mills work continuously throughout the year while the smaller ones lie idle for a quarter of the year due to lack of supply of raw bones. The annual crushing capacity of the existing bone mills has been estimated at 3.99 lakh tons

*Farm Bulletin No. 47 of the Indian Council of Agricultural Research.

With a view to augmenting bone-meal production in the country, it will be highly desirable to organise collection of bones in the rural areas on an intensive scale.

It has been estimated that the quantity of bone-meal required as fertilizer in 8 or 9 States alone was 36,340 tons while the total availability is 35,000 tons in the country. This means, there is an immediate need for stepping up the production of bone-meal in the country. This has, however, failed to gain much popularity as a fertiliser in some of the States because of its high cost and of the religious sentiments of the people.

Bone-meal is also an important mineral supplement in livestock feeding. It is used in small quantity in sterilised form as a constituent of the mineral mixture for livestock feeding. Its production within the country is, however, very limited.

Bone-meal is manufactured by different methods.

(*i*) *Rawbone-meal.*—is a bone-meal manufactured from bones which have been cooked for long periods in an open pan without steam pressure, and are, therefore, sterilised and safe for use.

The protein content of such meal is high, not less than 23 per cent, as only a small part of the ossein is removed during choking. It is used mostly for the feeding of poultry. An average analysis is as follows :—

	Per cent
Protein	26
Calcium	23
Phosphorus	11

and an appreciable amount of fat.

(*ii*) *Steamed Bone-meal.*—is prepared by cooking the bones under high pressure (wet or dry rendering). During the process of cooking the steam removes most of the proteins and fat. The average composition of the bone-meal prepared through this method is as follows:—

	Per cent
Protein	7
Calcium	32·5
Phosphorus	15·1

(*iii*) *Bone Ash.*—is the ash obtained by burning bones with free access to air. It contains 15.3 to 16.6 per cent of phosphorus.

Meat-meal.—Carcasses of fallen animals should be converted into meat-meal rather than incinerating them or burying into the ground or allowing them to be eaten by vultures and dogs. While preparing the meat meal the following three points should received special attention.—

(*a*) sterilization of the material;

(*b*) quick reduction of moisture before purification sets in;

(*c*) the removal of fat which goes rancid quickly.

Meat meal prepared by wet rendered method contains.—

Moisture	4·2%	
Crude protein	53·9%	
Digestibility of the crude protein	..	83·5%
Crude fat	24·3%	
Salt	..	0·7%
Bone	..	16·5%
Ash	15·1%	
	97·5%	

Meat and bone-meal is not only a good source of protein, but also supplies good amount of phosphorus and calcium as well as vitamin B. 12, which are so valuable from the stand point of animal nutrition. Proteins derived from meat or blood are well suited to correct the deficiency of amino acids present in the grass or grain. Because products such as meat-meal, and blood-meal contain practically no fibre, they are called "concentrates" as they add little to the bulk of the ration. Such concentrates, containing little fibre, are extremely important in pig and poultry feeding, as they allow the animal to have a higher intake of protein without increasing the volume of the food.

Glue and Gelatine

Glue is an impure gelatine. The colour of glue varies according to the manufacturers' requirements. Glue of good quality is practically free from smell, is unaffected by the atmosphere, and has great adhesive power. Gelatine is quite transparent, has a slight yellowish tint, is very hard and elastic, but brittle if bent too far. Gelatine, like glue, is derived from the cuttings of hides and skins and also from bones. But different treatments are given for obtaining if from hides and from bones. Bones yield the larger protein of the gelatine used, either as a food or for trade purposes. The raw materials for gelatine have to be selected with the greatest care and judgment; they must be quite fresh. The skins should preferably be those of calves and sheep and should be cut into pieces. The bones for this purpose are carefully picked.

There are 9 large scale glue manufacturing units within the country which are borne on the register of the Development Wing (Ministry of Commerce & Industry), with an installed capacity of 2,835 tons per annum. The total production of glue in these units during the past few years is as under:—

	Tons
1957	1,311
1958	1,203
1959	1,930
1960	1,835
1961	1,854
1962 (Jan.-May)	962

The production of glue/technical gelatine has been increasing very rapidly with the rising tempo of industrialisation.

Prior to May, 1960, the export of bone sinews and other glue making materials were licensed freely without any quantitative restrictions. Because the indigenous manufacturers of glue were finding it difficult to obtain adequate quantities of raw materials the export of these items has been restricted now.

Glue is not being imported at present. Only special varieties of gelatine which are not manufactured in the country are being allowed to be imported. The country is self-sufficient with regard to the production of glue/technical gelatine and efforts are being made to export this item from the country.

Considerable quantities of raw bones as well as crushed bones are being exported from the country at present from which the importing countries manufacture ossein and high grade gelatine. Recently licences were issued to 5 or 6 parties for the manufacture of ossein and high grade gelatine. The requirements of edible, pharmaceutical and photographic gelatine within the country are very limited and efforts are to be made for the manufacture of these items with a view to export them. Messrs. Leinor Knit Gelatine Co., Jabalpur, is expected to go into production very soon.

When some of these units go into production, the country's demand for special varieties of gelatine would be met and we would also be in a position to export considerable quantities of ossein and special gelatine. The requirements of bones for the manufacture of ossein and gelatine would have to be met from indigenous sources. Unless more efforts are made to collect and conserve bones from various accessible and inaccessible parts of the country it would become essential to restrict exports of bones in order to meet the requirements of the indigenous industry. The manufacture of ossein and gelatine for internal use as well as exports would also make available large quantity of di-calcium phosphate which could be utilised as manure.

To meet the increasing demand of glue by industries such as abrasives, adhesives, matches, cork, printing rollers, distempers, taxtiles and papers etc., it is necessary that an increased production of glue is ensured within the country. Already dearth of glue making materials is being felt by the manufacturers and it would be worthwhile to consider better collection of glue making materials such as hide cuttings, fleshings, trimmings, bones, etc. This would help in making adequate quantity of raw materials available to the glue and gelatine manufacturing units and considerable foreign exchange could also be earned by the exports of surplus bones, ossein and gelatine from the country.

Improvement in Flaying Methods

At present, the rights for flaying of fallen animals in the villages rest with the local *chamars* by tradition. The fallen animals are generally collected rather late and flaying is done with crude tools and implements. The quality of hides thus obtained is poor.

In Western countries also, until the beginning of this century, dead animals used to be buried and the system of incinerating the carcasses was introduced later. In recent years, processes have been evolved and employed for the conversion of carcass bye-products into materials useful for animal feeds or other purposes. Bone digestors, wet or dry rendering plants for preparation of meat-meal, bone-meal etc., and for extraction of fat have been introduced.

In India, steps were taken by some State Governments and non-official organisations such as Khadi and Village Industries Commission for encouraging the proper utilisation of fallen animals. The Khadi and Village Industries Commission is running a training centre at Kora Gramodyog Kendra, Borivli, Bombay, and has also established a number of flaying centres in various parts of the country. During the Third Five Year Plan, the Khadi and Village Industries Commission has decided to start 200 Intensive Flaying Units besides small flaying units which are already in existence. The number of units working, financial assistance given and production achieved during the year 1961-62 is given below:—

TABLE 2

Number of flaying units and centres and bone crushing units, financial assistance and value of production during 1961-62

Centre	No. of units working	Financial assistance provided	Value of Production
		Rs.	Rs.
Intensive Flaying Units..	5	3,20,000	3,25,000
Flaying Centre	226	16,31,720	11,23,000
Bone Crushing Units	12	45,600	19,000
TOTAL	243	19,97,320	14,67,000

The establishment of well-equipped *Charmalayas* has been included under the Gosadan Scheme by the Ministry of Food and Agriculture, for adopting improved methods of flaying, curing of hides and manufacture of bone-meal, meat-meal, etc. Eleven Gosadans have so far been provided with *Charmalayas*. Most of the other gosadans have facilities for flaying only. A model Training-*cum*-Production Centre at Bakshi-Ka-Talab near Lucknow has also been set up with financial and technical assistance from the Government of the Netherlands and the Food and Agricultural Organisation of the U.N. The following courses are conducted at this centre.—

1. A course of 4 months' duration in hide flaying, curing and carcass utilisation.
2. A course of one year's duration in vegetable and mineral tanning.
3. A course of one year's duration in footwear and leather utilisation.

So far 116 candidates have been trained at this centre in hide flaying, curing and carcass utilisation.

The services of F.A.O. Expert on hide flaying, curing, and carcass utilisation have been obtained, and his services are being made available to the States for setting up carcass utilization centres.

The need for maximum exploitation of the economic value of fallen animals is being realised increasingly now both by the Government and non-official agencies. Any improvement in the methods now adopted by the village Chamars in the utilization of carcass would go a long way towards ameliorating their economic condition. The subject of carcass utilization was also discussed at the 14th Animal Husbandry Wing Meeting held in Bangalore in July, 1961, and the recommendations that were made in the Conference deserves consideration and implementation by the Indian Council of Agricultural Research, Ministries and representative organisations. These recommendations deal with hide flaying and carcass utilization work for which the Animal Husbandry Department of the State Governments should have a separate section under the charge of a suitable qualified officer. It is also desirable that each State should establish a suitable number of carcass utilization and hide flaying centres with a view to preventing the present wastage.

(*a*) Such centres in rural areas may be located in a village or a group of villages to ensure the availability of sufficient number of carcasses to make them economic units.

(*b*) In urban areas, municipalities or corporations may be asked to take adequate steps to set up such centres in their jurisdiction in order to ensure fully the utilisation of carcasses.

Such carcass utilisation and hide flaying centres may be organised through the cooperatives of flayers and/or other interested parties. Where the formation of such cooperatives is not possible, the work may be entrusted to Panchayats or private bodies. Suitable facilities should be provided to train technicians in utilisation. Steps should also be taken to improve the design and to manufacture carcass utilisation equipment for handling a small number of carcasses economically. To ensure proper curing of raw hides and skins, the Government may supply curing salt free of cost to the hide flaying and carcass utilisation centres, as is being done in the case of fish curing yards. The problem is really nation-wide and complicated, because not only was it necessary to organise a machinery for collection of carcasses and setting up centres for utilisation, but it is also necessary to set up subsidiary industries to utilise the finished products like bones, meal etc. Further, social and economic factors are also involved. The Chamars and similar castes who do this work are very poor, backward and have about the lowest social position in rural society. Their work is also looked down upon. In recent years there has been a tendency among Chamars in many areas to give up this work in a bid to raise their social status. The result is that the work is not being done by castes like Bhangis, who are even lower in the social scale and is mostly done even more indifferently and inefficiently than in the past. There is need for education to remove this stigma against this work and to emphasise the economic value and essentially of the materials.

REFERENCES

1. "Farm Bulletin No. 46" of the Indian Council of Agricultural Research.
2. "Agricultural Marketing Series 124" (Report on the Marketing of Animal Fats and certain important bye-products in India).

IX. FISHERY WASTES

The total marine fish landings during the year 1961 amounted to 683,569 metric tons. With the large number of mechanised boats likely to be available in the coming years, with more extensive use of mechanised fishing and exploitation of offshore fisheries it is expected that the marine fish catch will go up considerably during the Third Plan period. At present, the major portion of the catch in marine fishes is contributed by the States of Kerala, Mysore, Maharashtra and Gujarat. The most important varieties of fish landed are: mackerel, sardine. elasmobranch, Bombay duck and miscellaneous, the latter comprising nearly 386,000 metric tons or more than half of the total. The waste from fisheries arise from three sources: (i) surplus fish due to heavy landings without corresponding facilities in economic marketing for human consumption, (ii) material obtained as waste during preservation of fish by freezing, canning, drying and other processes or when only an organ or a component of fish tissue is utilised and (iii) inedible or small fish of low market value which may be 5 to 15 per cent of some commercial catches. The important types of fish which contribute most of waste available in these ways are oil sardines, mackerel, elasmobranch, leiognathu, gazza, eels and Bombay duck. The landings of these types during the last two years are shown in the following table :

TABLE 1

Landing of Fish by Types during 1960-61 *and* 1961-62

Type of fish	1961-62 (thousand metric tons)	1960-61 (thousand metric tons)
Oil Sardines	167·88	189·02
Mackerels	34·49	133·65
Elamobranchs	33·55	35·56
Leiognathus & gazza	15·96	16·39
Bombay duck	93·84	108·56
Eels	11·38	6·14

In almost all the maritime States in India, even though the by-products and other fishery products are manufactured and marketed in large quantities, no precise information on production is available for a number of the products. This is mainly due to the fact that the industry is in the hands of private traders. The by-products industry in India is still in a nascent stage; but the economics of fishing industry require the establishment of such an industry. The industries existing at present in India which require expansion, and re-organisation are those concerned with manufacture of sardine oil, fish meal and fish manure, shark liver oil, fish maws and shark fins. India earned Rs. 32 lakhs in foreign exchange in 1959 by exporting fishery by-products to the neighbouring countries. The world's disposition of fish catch will indicate the importance of by-products manufacture in fishery industry as indicated below :

	Percent
Marketing fresh	42
Freezing	8
Canning	24
Reduction to meal & oil	14
Miscellaneous purpose	3

From the surplus fish landed and from the wastes from the fish processing industry, the following important products may be manufactured.

1. Fish meal
2. Fish oil (body oil)
3. Liver oil
4. Fish manure
5. Peptone and other degraded products
6. Shark fins and Fish maws
7. Fish glue and fish gelatine
8. Pearl essence

1. *Fish meal* :

Fish meal is one of the most valuable by products of the fishery industry. In countries, where fish processing industry is well developed fish meal is produced from head, viscera and other waste materials obtained in this industry. In India, however, these wastes are not available. The main sources of fish meal in India are : (a) residues left after extraction of oil from oil sardines, (b) low quality fish (trash) caught together with high quality fish, (c) fish caught in excess of the market requirements or processing facilities.

The fish meal production in India was mainly encouraged in the past for export to Western countries, and more than 6,000 tons per annum were exported till recently,, when the excess fish meal production from Peru brought down the world market prices. However, with the development of poultry and dairy production, the demand for fish meal in the country is increasing steadily. Production is not sufficient to meet this demand. In the coming years, there is likely to be an acute shortage of fish meal in India, hence the production of fish meal should be given encouragement.

The main raw material for production of fish meal in India are : (1) sardine guano left after extraction of oil from oil-sardine, (ii) trash fish, and (iii) wastes from processing industry.

It is possible to get 30—40 thousand metric tons of fish meal from the present sardine landings. This material (sardine guano) is at present mainly used as manure which is, to say the least, a very wasteful use of valuable protein material. The guano left after extraction of oil from cooked and preserved sardine still contains sufficient oil to reduce its value as fish meal. Hence, the utilisation of this material will to a certain extent depend on the above-development of better method, of extraction of oil so that residual oil in guano is small. As sardine oil extraction is now carried out in small units, the production of fish meal from guano may also be carried out in small units. While sun-drying may be used, the small rotary dyer developed at Central Institute of Fisheries Technology will be useful for small scale production.

It has been estimated that nearly 10 per cent of the fish landed are not economically utilised. Trash fish and excess landings account for this quantities. They can be utilised for fish meal production. Fish meal from this source is now produced by small scale sun-drying followed by grinding of the dried material.

The quality of this product is generally poor due to chemical alteration and admixture with dirt, the product is often contaminated with salmonelles and other pathogenic bacteria and hence is not generally suitable for poultry or dairy needs. Improved production of fish meal by modern equipment whereby the nutritive value of the fish meal is retained and the product is free from pathoganic bacteria has been demonstrated in pilot plants set up at Bombay Unit of the Central Institute of Fisheries Technology and similar Unit is being set up at Jafrabad by the Gujarat Government. (Details of the design working and economics of a unit is given in the Appendix). These plants have got a capacity of 10 tons of fish meal per day. As the landing of fish is widely dispersed, securing of enough raw material for running the mechanised fish meal plants may be difficult for the present. But, with the increasing mechanisation of fishing boats, the landings of fish will be more and more concentrated at the fishing harbours and supply of the necessary amounts of fish for running such plants should not be difficult. However, in the meantime production of fish meal by small scale plants should be attempted.

In the prawn freezing and canning industry, shells and heads from an important waste product which contains roughly 30—40 present of protein (dry basis) and which can be usefully converted into fish meal. On the basis of present production in these factories, estimated production of the meal will be roughly 120 tons. The dry prawn pulp industry can similarly yield roughly 250 tons of meal. The fish meal from shell and heads is low in protein value but it is mixed with better quality meals from other sources to bring up the protein content to 50 per cent level.

2. *Fish Oil* :

One of the important by-products of the fishery industry is fish oil. This can replace vegetable oils in many of its uses, *e.g.* in the manufacture of soap, cosmetics, hydrogenated fats, vehicle-paint etc. It will be a valuable supplement to vegetable oil supply in the country.

The most important source of fish oil in India is oil sardines. In 1960-61, 189,000 metric tons of oil sardine had been caught. Oil sardines contains about 16% of its weight as oil. Assuming that the yield of oil at 10% of the weight of the fish, it is possible to get about 19,000 metric tons of sardine oil. However, the amount of sardine oil produced in India in recent years is roughly 4 to 5 thousand tons per year. Thus it will be observed that there is considerable scope for development of this industry.

Most of the sardines are landed on the Malabar and South Canara coasts; small amounts are available at most places on the Western coast. or economical extraction of sardine oil, however, extraction units should be established in the area between Cochin in the South and Karwar in the North. However, as the landing ground are dispersed, it will be desirable to encourage small scale production of the oil by the fisherman. The oil produced could be collected for further processing at Central Stations, located at Calicut or at Mangalore.

A larger production of sardine oil, however, would be limited by its demand. At present sardine oil is mainly used for coating the local fishing boats. Due to its poor quality, it does not find a market in other industries like cosmetics, soap, hydrogenated fat, leather, tile etc., which could use a good amount of this oil. Good sardine oil can also be used in the canning of fish. It will be necessary to improve the quality of the oil before the expanded market for the material is realised. Investigations at the Central Institute of Fisheries Technology have demonstrated that the main reason for poor quality of the oil is faulty processing by the small scale processors. An improved method of processing and extraction has been developed at the Institute and if this simple modified method is widely used, it will result in production of much better quality of oil. It has been shown that the free fatty acid in an average commercial oil is 11—35 per cent. while in oil produced by improved methods it is less than 1 per cent. The colour of the latter is also much lighter, while the former is normally dark brown.

The Central Food Technological Research Institute, Mysore, has also developed a process of refining of sardine oil for improving the quality of the commercial oil. The economics of the process is still under investigation.

If the modified method of processing and extraction is used widely for obtaining the oil and if the improved refining method suggested by the Central Institute of Fisheries Technology is used for bettering the quality of low grade commercial oil, the products thus obtained will find wide market and a valuable material which is mainly wasted at present can be utilised. Valuable derivatives like sulphonated oils and other modified components and derivatives may also be produced from sardine oil.

There has not been much work in this field and these aspects of utilisation of sardine oil should be investigated. Some species of fish like skate and ray are caught in fairly large quantities (4,500 tons) every year. The liver of these fish contains good amount of oil which, however, is not rich in vitamin A like shark liver oil. From these livers, it should be possible to extract more than 200 tons of oil which can be used in the same way as sardine oil. The landing of skate and ray is, however, dispersed and the extraction has to be carried out on a small scale. It will be desirable also to carry on detailed investigations in chemical composition of the livers of skate and ray with a view to finding out commercially important compounds which may be obtained from them. No reliable data are available on the detailed chemical compositions of these oils. As these are liver oils, it is very likely that they will contain some valuable chemical components which are not normally present in body oils of the fish.

3. *Liver Oil Industry* :

Fish liver oils are highly valued for their high content of Vitamin A. Elasmobranch fishes, particularly sharks provide one of the best vitamin A rich oils. The total catch of Elasmobranchs in the year 1960-61 was 35,500 metric tons. With the introduction of hook and line fishing and opening of rich fishing grounds, the catch of sharks will go up very rapidly and there will be a corresponding increase in the supply of liver oils and the industry will be able to cater to the over increasing demand for Vitamin A. At present, three plants are producing the vitamin rich oils and vitamin concentrates in India. These are located at Trivandrum, Kozhikode and Bombay. Small plants are also operating in West Bengal and other States. There is provision for establishment of a shark liver plant in Gujarat and in Andhra. As there is going to be an alround development in the fishing activity, it is advisable to have shark liver oil plants in each of the maritime States to process and refine the oil produced in the different centres of the State. The following figures show the production of the oil at different States.

Kerala	Figures not available—above 75 tons (roughly).
Maharashtra	10-15 thousand gallons.
Gujarat	50 tons.
Andhra	1·2 tons.
West Bengal	Figures not available.

4. *Fish manure* :

Fish manure like fish meal is a product of high nitrogen content. It is valued for its nitrogen and phosphorus content. It should be prepared only when the raw material is not suitable for manufacture of any product for human consumption or for animal feed. Generally spoiled fish, small shell fish, inedible fish are used for production of fish manure. Sardine guano is sold as a fertiliser in many places. This industry cannot be organised as an independent industry. It should always be attached to a fish processing industry like curing, canning and/or freezing. In the curing industry, the guts and gills form the waste materials and in canning industry, the tails, heads and viscera are the waste materials. These materials roughly comprises 15—20 per cent of the weight of fish. Assuming 50 per cent of the mackerel catch is utilised for the Colombo type of curing, 1000 metric tons of manure can be produced from the waste material. This type of curing is largely done at Malpe and Karwar. At Malpe, nearly 30 tons of manure is produced from this waste material. In Karwar, there is no organised collection of material and the waste is thrown on the beach. No production figures were available at other centres. Examination of the quality of different types of manures produced on the West coast showed a gross admixture of sand. Although the total amount of fertiliser available through fish manure is not large, but because of its high nitrogen and phosphorus content it is valued. The method of production in a better way without the admixture of the sand, and addition of saw dust and copper sulphate solution (1-2 lbs. per ton of meal) will keep the material in good condition during the storage period. At present, it is produced in Calicut, Malpe, Adirampatnam, Rameshwaram. The production can be started at the curing yard in the different states under the agencies of State Governments. Not much work is to be done in this except to organize the industry. In Gujarat 1200 tons of manure was produced at Jaffarabad, Nawabunder and Salayar.

5. *Peptone and other degraded products* :

At present, products of this type are not manufactured in India. These are popular in South East Asian countries. Small size of fishes like leiognathus and gazza species and clupeids for which gutting is a difficult problem can be utilised for the production of degraded protein products like fish sauces. These types of fish are abundantly landed along the East Coast. The total landings of the varieties which can be converted is roughly estimated to 35,700 metric tons. The percentage yield of the sauce is nearly 30 and the cost of production works out to be Rs. 1.60 per kg. of sauce. The procedure for manufacture is simple and it can be done in any fishing village. The method developed at the Central Institute of Fisheries Technology can be readily adopted for manufacture of this product. This is a cheap protein food which can be added to the rice diet or to soups. This industry can also be developed on a cottage scale.

Work on preparation of sauces from different types of fishes which are not highly priced and on their storage life is necessary. Investigations on the preparation of protein rich foods and their storage characteristics will be taken up at the Central Institute of Fisheries Technology.

Production of hydrolysates from shark flesh which are at present wasted should also be taken up. This industry can be located at shark fishing centres, to avoid the transportation of the raw material and its deterioration during transportation. As the flesh of the shark is not much relished by the majority of the people the cost of the raw material is small.

6. *Shark fins and fish maws* :

The whole quantity produced in India is exported to countries like Hongkong, Singapore, Malaya and U.K. where it is utilised for the preparation of finer finished products in the forms of shark-fin rays and isinglass. The figures give a rough idea of the export of these products.

	Quantity in Kg.		Value in Rupees	
	1960	1961	1960	1961
Shark fins and fish maws	2,98,420	2,92,250	20,73,754	22,29,494

With increase in shark fishing round the coast, the shark fin industry will also improve. Fish maws or air bladders of the eels and cat fishes are dried at the curing yards in all the States and sent to Bombay for export. This industry can be developed along the Maharashtra and Gujarat coasts and at Ullal in the Mysore State. In the Gujarat State about 75,000 lb. of fish maws and 40,000 lb. of shark fins are produced for the export market. In Maharashtra the production of fish maws is roughly 5,000 mds. and roughly 2,500 mds. of shark fins are produced annually.

Work on the production of finer products in India is necessary to get a better price for these products. Work on improvement in the method of production and preparation of the finer products will be taken up at the Central Institute of Fisheries Technology.

7. *Fish glue and fish gelatine* :

At present there is no glue industry in India. This can only be started as an adjunct of the large scale processing industry, in which skins and heads form the waste materials. Preliminary experiments conducted at the Technological Laboratory at Bombay showed that the glue and high grade gelatine prepared from fish had similar properties when compared with other similar products.

8. *Pearl essence* :

This is obtained from the scrapping of the outer skin of ribbon fish. At present the fish is sold as fresh or cured. It is yet to be seen how the products will be after the lustre particles are removed by scrapping or agitation. The percentage availability of the raw material, the labour cost and processing costs will have to be worked out before the process can be released to the industry.

REFERENCE

FISH-MEAL

Author	Year	Note
Fisheries Development Adviser, Ministry of Food and Agriculture.	1963	Survey and utilisation of fisheries wastes and by-products.

APPENDIX

Design, working and economics of preparing quality on a small scale :

Fish meal is made from lean, miscellaneous fish which do not have good market and waste parts of the fish such as heads, fins, viscera etc. It is a good source of protein, vitamins particularly B-Group vitamin, minerals and other growth promoting unidentified factors. The main source of the raw material for this product in this country will be the miscellaneous fish, landed all along the sea-cost, by the individual fishermen from their country crafts as well as from mechanised fishing boats. However, due to the difficulties of transport, preservation etc. it has not been possible to collect these miscellaneous fish from even a group of villages and to utilise the same for the manufacture of fish-meal. As a result of this, major parts of this fish is wasted, particularly during the rainy days, since it cannot be utilised for any other purpose. During the fair days some of these miscellaneous fish are sun dried, ground and sold as a fish-meal. However, this method of producing fish-meal has many disadvantages. The product will be low in its biological values since the available lysine contents will be very much less. It is generally highly contaminated with sand and mud lowering the protein values and may not be free from Salmonella and other pathogenic bacteria, and the product can be manufactured during the dry season only.

Given a suitable equipment to produce fish-meal at the fish landing sites it is felt that not only such fish that are going waste at present can be usefully utilised but a product of a better quality can be produced. Large quantities of fish-meal (about 6000 tons annually) were being exported from India till few years back. However, the export of this product has very much declined recently. The export can be re-established only if a fish-meal free from Salmonella and other Pathogenic bacteria as required by the importing countries and having the requisite protein content is manufactured. The following are the other specifications for fish-meal laid down by the Ministry of Food and Agriculture, and notified by the Ministry of Commerce and Industry in the Export Instruction No. 95/59 dated September 12, 1959.

Protein	45% minimum
Moisture	12% maximum.
Insolubles	7% ,,
Fat	7% ,,
Salt	7% ,,
Size	1/4 (particle size).

The equipments for the manufacture of fish-meal free from Salmonella and to the specifications given above, the design and particulars for which are enclosed herewith, would be suitable for installing at the fish landing places where about ½ ton of miscellaneous fish is landed during the fishing day. The process for the manufacture is as below :

The fresh miscellaneous fish waste such as heads, fins, entrails etc. are cooked in the dryer for 30 minutes with 5 p.s.i.g. of steam in the outer jacket. The cooked fish is then removed from the dryer and pressed under screw press in 3 or 4 lots of suitable quantity (about 300 lbs. at a time) to remove the stick water. The moisture contents of the pressed and cooked material will be reduced to nearly 50 per cent from the original contents of about 70 per cent. The pressed material is then put in a rotary dryer for further drying with 5 p.s.i.g. steam in the outer jacket. The material will be dried till the moisture content is reduced to about 10 per cent. Approximately about 6 hours will be necessary. The material is then pulverised in a hammer mill to a required particle size (between 1/4 to 1/16)then seived to remove any scales, fibre etc. and packed in polythene lined gunny bags or bags of bitumen coated paper (kraft paper bags) if required in smaller quantities. The final product available from 1120 lbs. of raw material will be about 350 lbs.

Estimates for Capital and Recurring Expenditure for a Fish-meal Plant of ½ Ton (Raw Material) Capacity

I. *Space Requirement*:

Total land 1,400 Sq. ft.	Rs.	4,200·00
Factory Space (closed) 700 Sq. ft.	Rs.	7,000·00
	Rs.	11,200·00
Construction, water & electrical fittings, sanitary fittings etc.	Rs.	3,500.00
	Rs.	14,700·00

II *Equipment and Machinery :*

(1) *Boiler :* 1 No.		
75 to 100 lbs. working pressure, normal evaporation 100 lbs. water per hour.	Rs.	2,500·00
(2) *Double jacketed rotary drum dryer :* 1 No.		
2′—10″x5′ length : overall size, inner drum size 2′—6″ x5′ length, made out of 1/8″ mild steel plate. Speed 20 R. P. M. with motor of 3 h. p. 3 phase, 400 volt 1,440 R. P. M.	Rs.	13,000·00
(3) *Pulveriser :* Hammer type—1 *No.*		
Capacity 100 to 160 lbs/hour suitable to pulverize dried fish to the particle size of 1/16″	Rs.	4,000·00
(4) *Seives*—Mesh size 16 per sq. inch with wooden frame. Size of the seive 2 x2 —2 *Nos.*	Rs.	100·00
(5) *Screw press :*		
Base plate 3′x3′		
Upper plate 3′x′3′x1″ thick		
Height 16′		
Handle 2″		
Screw diameter 2″		
Screw Perimeter 7″—1 *No.*	Rs.	600·00
Total ..	Rs.	20,200·00

On per year basis

No. of working days : 200.

III. *Services (Electricity, Fuel etc.)*

Electricity : 3,600 Kw @ 18 Kw. per day @ 12 nP. per unit ..	Rs.	312·00
Fuel : Kerosene Oil 800 galls. @ 4 galls per day @ Rs. 1·75 per. gal	Rs.	1,400·00
	Rs.	1,712·00

IV. *Staff requirement*——

Unskilled :

Male Workers—2 —@Rs. 2 per day	Rs.	800·00
Skilled :		
Mechanic—1 — @ Rs. 3 per day	Rs.	600·00
	Rs.	1,400·00

V. *Raw Material :*

(i) Miscellaneous Fish, Fish waste etc. 100 tons @ Rs. 45 per ton	Rs.	4,500·00
(ii) Gunny bags, polythene lined 700 Nos. @ Rs. 190 per 100 bags	Rs.	1,330·00
	Rs.	5,830·00

I. *Capital Expenditure :*

(A) *Fixed capital :*

(i) Land & Buildings	Rs.	14,700·00
(ii) Equipment & Machinery	Rs.	20,200·00
TOTAL ..	Rs.	34,900·00
(B) Working capital (per year)	Rs.	8,942·00

NOTE :—Production cost 12 nP. per lb. (excluding the depreciation on the Fixed Capital). The figures given bove are mere approximations and are likely to vary from region to region depending on the availability of the raw material labour, electricity etc.

Part II

INDUSTRIAL WASTES AND BY-PRODUCTS

सत्यमेव जयते

सत्यमेव जयते

X. BLAST FURNACE SLAG

Blast furnace slag is an essential by-product in the manufacture of pig iron. This material, which was considered a waste some years ago, has come to be regarded as valuable. It finds its greatest use in the road-making and building industries in foreign countries. In India, however, it is mostly a waste material and its disposal presents a serious problem.

There are three types of blast furnace slag in commercial use, known as air-cooled or hard slag, granulated or water-quenched slag and light-weight or expanded slag. Air-cooled slag is the product cooled naturally from the molten state. It is prepared as a coarse aggregate by crushing and screening. It is used in concrete as a substitute for other coarse aggregates, particularly in road construction. Its hydrophobic properties together with the rough surface permit a strong bond in asphalt pavement. It is also used as ballast for rail tracks, filter media in sewage disposal and for sea defence walls and river bank protection. Experiments carried out in the Central Building Research Institute, Roorkee have shown that Indian slags can be used as aggregate in concrete comparable in properties to that obtained from crushed stone aggregates.

Granulated slag is the glassy product obtained when molten slag is chilled rapidly by immersion in water. Granulated slag has hydraulic properties and can replace Portland cement clinker to a considerable extent in the manufacture of cement.

Expanded slag is the light-weight product formed when molten slag is foamed with limited quantities of water. The rapid generation of steam expands the slag into a light vesicular material. After crushing to suitable sizes, it is used as a light-weight aggregate. The crushing strength of concrete made with foamed slag aggregate is comparable with that using other types of light-weight aggregate. Experiments carried out in the Central Building Research Institute on expanded slag from the Mysore Iron and Steel Works and from two blast furnaces in the Durgapur Steel Plant, have indicated the suitability of these slags for making light-weight aggregate. The Hindustan Housing Factory, Delhi has also carried out experiments in making panels with foamed slag and the results have been encouraging.

Blast furnace slag cement.—The use of blast furnace slag for making Portland blast furnace slag cement is now well established and there are a number of foreign specifications and an Indian specification (IS : 455-1962) on the subject. All major steel producing countries are utilising their blast furnace slag to augment the supply of cement. About 40 per cent of the cement production in Germany consists of cement with an admixture of slag, whilst over two million tons of such cement are produced in France. In addition to Germany and France, the major countries producing Portland blast furnace slag cement are Belgium, U.K., U.S.A. and Mexico.

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Considerable amount of work has been done in these countries on the composition and hydraulicity of their slags and on the properties of cement containing varying quantities of slag and other related aspects of slag cement manufacture and its use. It has been shown that even finely ground slag alone can be used as cement having almost similar properties as Portland cement in the presence of suitable activators. A few results on compressive strength obtained by research workers in Calcutta University, which are tabulated below, illustrate this point.

TABLE 1

Strength of slag-lime-gypsum mixtures

Composition	Compressive strength (lbs. per sq. inch) after		
	7 days	28 days	6 months
1. Slag—85 .. .. Lime—15 Gypsum—0	1,017	2,066	2,667
2. Slag—80 .. .. Lime—15 Gypsum—5	1,233	2,466	2,800
3. Portland cement	1,166	1,900	3,266

Properties of slag cement and its suitability for specific types of works.—As a result of experiments it has been established that the final strength of Portland slag cement is of the same order as that of straight Portland cement, if not better. But its initial strength is lower than that of Portland cement. Due to its slow rate of setting, the heat of hydration develops slowly so that the volume expansion of the concrete mass is less than that in the case of Portland cement. This gives slag cement an advantage over Portland cement in making massive concrete structures like dams, embankments, foundations etc. The other advantage of slag cement over Portland cement is its better resistance to sea water, sulphates and other chemicals in solution. The resistance to chemicals increases with the increase in proportion of slag in slag cement. This property makes slag cement better suited for marine structures as well as other under-water or under-ground structures. The same amount of protection is afforded by slag cement to embedded steel as by Portland cement.

Because the final strength of slag cement is comparable with that of Portland cement, it is suitable for all works where Portland cement can be used, except where a higher initial strength is a specific requirement.

Granulation of slag.—Granulation is a 'must' for the utilisation of slag for the manufacture of cement, otherwise the slag does not possess hydraulic properties. It is said that the process of granulation arrests crystallization in the molten slag which solidifies as a glass during chilling with water. The hydraulicity of granulated slag is stated to be proportional to its glass content, and the higher the temperature of the slag the greater the proportion of glass in the granulated slag. Moreover, granulation makes the slag friable so that it can be easily ground with less consumption of power.

The process of manufacture of Portland blast furnace slag cement is simple and consists of inter-grinding Portland cement clinker and granulated blast furnace slag in pre-determined proportions in a mill to the required fineness with a small addition of gypsum. The proportion in which slag may be used varies from 25 to 65 per cent depending on its quality. The resultant slag cement must conform to the following specifications :

TABLE 2

Specifications for composition of slag cement

	Not to exceed (per cent)
MgO	8·0
Mn_2O_3	1·5
SO_3 (Sulphur trioxide)	3·0
S (Sulphide sulphur)	1·5
Insoluble residue	1·5
Loss on ignition	4·0

Slags available in India.—Production of slag in India is increasing rapidly alongwith the increase in iron production. The quantity of slag produced in a blast furnace varies from 3/4 to one ton for every ton of iron produced, depending on the quality of the raw materials used. In terms of volume this represents over twice as much as iron. The disposal of this large quantity of slag as waste takes up a lot of useful space near the iron and steel works and represents a charge on the iron produced. The present production of blast furnace slag in India is estimated at 3 million tons per annum, distributed between various steel plants as follows :

TABLE 3

Production of blast furnace slag in India

Steel plant	Thousand tons of slag
Rourkela	666
Bhilai	715
Durgapur	767
Tata Iron and Steel Co. (TISCO)	580
Indian Iron and Steel Co. (IISCO)	240
Mysore Iron and Steel Works	33
Total	3,001

By the end of the Third Five Year Plan, slag production is expected to rise to 6-7 million tons a year. In addition, a large quantity of slag has accumulated near the steel plants over the years.

Composition of Indian slags.—The chemical composition of slag coming out of different steel plants is tabulated below :

TABLE 4

*Chemical composition of slag (per cent)**

Component	Rourkela	Bhilai	Durgapur	TISCO	IISCO	Mysore
SiO_2	31·6	34·7	31·1	30–34	28·5	30–37
Al_2O_3 ..	24·2	17·9	25·3	22—28	29·5	25—30
CaO	37·1	39·1	35·9	35·5–38·2	36·2	26—30
MgO	4·8	4·9	4·8	3·0–3·6	3·0	2–4
FeO	0·6	0·6	0·6	0·1–0·9	0·9	2–3
MnO	N.A.	1·4	1·4	0·5–1·3	0·5	0·56—1·25
SO_3	N.A.	1·2	0·77	Trace	1·0	Trace

N.A.—Not available

*Data collected by the Slag Cement Committee and from the Central Building Research Institute, Roorkee.

According to Indian standard specifications, the composition of a slag suitable for cement manufacture should vary between the following limits :

TABLE 5

Specifications for composition of slag for cement manufacture

	(Per cent)
SiO_2	27—32
Al_2O_3	17—31
CaO	35—45
MgO	0—17
FeO	0— 1
Mn_2O_3	0— 2
S	0— 2

Slag Cement Committee.—A Slag Cement Committee was constituted in 1960 by the Ministry of Commerce and Industry to promote the manufacture of slag cement. In addition to the Development Officer (Mineral Industries), Development Wing, Ministry of Commerce and Industry, the Committee consisted of the representatives of the Hindustan Steel Ltd. and the Planning Commission and the Managing Director of Associated Cement Companies. However, the parties holding licences for the manufacture of slag cement were invited to all the meetings. The Committee met thrice and came to the conclusion that, judging from the composition of slags furnished by Hindustan Steel, the Indian slags were suitable for manufacturing slag cement. The Committee recommended that Hindustan Steel should instal granulation plants at Bhilai, Rourkela and Durgapur as early as possible.

Manufacture of slag cement in India.—A beginning has been made with the utilisation of blast furnace slag for cement manufacture. The following two factories are already in production :

Name of the factory	Annual capacity for cement in tons	Source of slag
1. Mysore Iron and Steel Works, Bhadravati (Mysore).	18,000	Mysore Iron and Steel Works, Bhadravati.
2. Associated Cement Companies Ltd., Chaibasa (Bihar).	170,000	Tata Iron and Steel Co., Jamshedpur.
Total	188,000	

In addition, the following schemes have been licenesd for the manufacture of slag cement

Name of the licencee	Date of issue of licence	Annual capacity in tons	Expected source of slag
1. Orissa Cements Ltd., Rajgangpur (Orissa).	January, 1956	360,000	Rourkela Steel Plant.
2. Associated Cement Cos., Sindri (Bihar).	February, 1956	170,000	Durgapur Steel Plant.
3. Associated Cement Cos. Durg (Madhya Pradesh)	June, 1956	370,000	Bhilai Steel Plant.
4. Durgapur Cements, Durgapur (W. Bengal)	March, 1957	240,000	Durgapur Steel Plant.
5. Rohtas Industries, Dalmianagar (Bihar).	March, 1961	220,000	Do.
6. Sone Valley Portland Cement Co., Japla (Bihar).	Do.	170,000	Do.
7. Kohli Finance (P) Ltd., Raipur (M.P.)	Scheme approved but licence not yet issued.	325,000	Bhilai Steel Plant.
8. Khemchand Rajkumar, Bhilai (M.P.)	Do.	197,000	Do.
	Total	2,052,000	

Of these schemes, only Associated Cement Companies, Durg have made some progress. According to present expectations, they will start production by the end of 1963. Others have not made much progress. The main difficulty in the way of implementation of these schemes so far was the uncertainty about the availability of granulated slag. Following the recommendation of the Slag Cement Committee, Hindustan Steel have initiated steps to instal granulation facilities at the three steel plants at Bhilai, Durgapur and Rourkela. A plant capable of producing 650,000 tons of granulated blast furnace slag per annum has been imported from the U.S.S.R. for installation in the Bhilai Steel Plant. It is expected to be commissioned by the end of

1963. Another plant designed to produce 246,000 tons of granulated slag will be imported under the expansion programme. The erection of this plant will be completed by the end of the Third Plan period. The terms and conditions of sale of granulated slag to Associated Cement Companies, Durg are under negotiation and are expected to be finalised in the near future. These terms will also apply to the other two companies *viz.* Kohli Finance (P) Ltd. and Khemchand Rajkumar.

A decision has been taken to instal a slag granulation plant at Durgapur. The Central Design and Engineering Bureau of Hindustan Steel is preparing a project report based on technical studies conducted in the U.K. The installation of this plant should be expedited.

According to the tests made by M/s. Orissa Cements Ltd., the slag at Rourkela is not suitable for cement manufacture because of its high manganic oxide and low calcium oxide contents. This conclusion is at variance with the findings of the Slag Cement Committee. Arrangements are, therefore, being made to carry out further tests in the Central Building Research Institute, Roorkee and Govt. Test House, Alipore.

The production of slag cement can augment the supply of cement more expeditiously than setting up additional capacity for ordinary cement. The requirements of foreign exchange for importing plant and equipment are also lower in the case of slag cement. All the requirements of cement machinery are not yet met from indigenous sources. Even the plants fabricated in the country require imported components. There is also some economy of fuel and power when slag is used in the manufacture of cement because an equivalent quantity of clinker does not have to be produced.

It would appear that the schemes licensed for the manufacture of slag cement have not progressed satisfactorily. In view of the acute shortage of cement in the country, immediate steps should be taken for the manufacture of slag cement on a fairly large scale.

Other uses of slag.—Blast furnace slag can be used for making slag wool for insulation purposes and in glass manufacture. M/s. Punj and Sons have been manufacturing and marketing slag wool under the trade name of 'Lloyd Wool'. They are producing slag wool using slag from the Tata Iron and Steel Works, Jamshedpur. The wool has been used for heat and sound insulation in place of asbestos.

Use of blast furnace slag for making glass was investigated in the U.S.A. and U.S.S.R. as early as 1920's. For making transparent glass as well as black and opal glass, the advantages of using this by-product were well recognised. The slag glasses were always superior to the corresponding soda-lime-silica glasses in respect of strength, chemical resistance and thermal properties.

Blast furnace slag in finely powdered condition has been used in the U.S.A. as a soil additive with good results. The increase in crop production associated with such additions depends to some extent on the fineness of slag. Slag addition is specially useful for acidic soils and for soils deficient in calcium.

It appears that the use of blast furnace slag as a raw material for glass-making and as a soil additive has not been investigated in India so far. It is recommended that the Central Glass and Ceramic Research Institute, Calcutta and the Indian Agricultural Research Institute, New Delhi should take up investigations on these aspects of slag utilisation.

Large quantities of river sand are used for stowing of mines as a measure of safety before these are abandoned. River sand has other uses *e.g.* for building purposes. It is felt that blast furnace slag should be used for stowing purposes, wherever feasible. It has been used for this purpose in some mines in European countries. The Central Mining Research Station, Dhanbad should investigate the feasibility of using blast furnace slag for stowing purposes as there is a shortage of stowing material in a number of places in the country.

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XI. BASIC SLAG

The necessity for manufacturing high grade steel from phosphorus iron ore led in 1879 to the discovery of a process for the elimination of phosphorus from cast iron. This is known as Thomas process in which high quality steel is produced and in addition the phosphorus and silicon of the ore form a phosphatic silicate of lime and magnesium which is recovered separately in the form of a slag fertiliser of great agricultural value. This slag ground to a very fine powder appears blackish grey which is only slightly hygroscopic and quite odourless. This fineness of grinding is a major factor in causing the even diffusion of the fertiliser within the soil. The product is highly soluble in a 2 per cent citric acid solution (Wagner method) and is sold as high grade basic slag which is a basic phosphatic fertiliser. The iron ores in Europe are rich in phosphorus and, therefore, the basic slag produced there contains a fairly high percentage of phosphoric acid, in addition to a large number of other fertilising elements. The average composition of Thomas basic slag is the following :—

TABLE 1

Average composition of Thomas basic slag

Constituent	Percentage
Phosphoric acid (P_2O_5)	10—22
Active lime (CaO)	40—50
Magnesium (MgO)	2— 3
Silicon (SiO_2)	6— 8
Manganese (MnO)	2— 8

It has been estimated that 45 kgs. of Thomas basic slag supply about 36 kgs. of elements essential for soils, plants and animals.

The world production of basic slag has risen from 5.2 million tonnes in 1951 to 6.6 million tonnes in 1958. It also follows that the production of basic slag will continue to increase in direct proportion to the expansion of steel production.

Most of the phosphoric acid in the basic slag is in a form soluble in 2 per cent citric acid and is, therefore, available to plants. In addition, the high content of active lime in the material acts as an amendment for the correction of acidity in acid soils.

Composition of Indian basic slag :

Indian iron ores are poor in their content of phosphorus and the basic slag produced from Indian iron ores contains about 38—46 per cent calcium oxide, 6—8 per cent magnesium oxide and 2—5 per cent phosphoric acid and some essential minor elements. The basic slag of the steel melting shop No. 2 of the Tata Iron and Steel Company, however, contains about 7.24 per cent phosphoric acid. Thus, the Indian basic slag is primarily a rich source of lime and secondarily a source of phosphoric acid. The chemical analyses of the basic slags from different steel factories are given in Tables 2 to 6 below :—

TABLE 2

Analyses of basic slags produced in 3 steel melting shops of the Tata Iron and Steel Co. Ltd., Jamshedpur.

(Per cent)

Ingredients	Steel melting shop No. 1	Steel melting shop No. 2	Steel melting shop No. 3
SiO_2	19·52	15·08	17·30
Al_2O_3	3·27	4·03	1·76
FeO	12·70	12·20	16·13
Fe_2O_3	1·47	4·03	2·15
MnO	4·80	7.25	3·00
CaO	45·50	43·20	48·30
MgO	9·50	6·87	8·27
P_2O_5	2·86	7·24	2·74

TABLE 3

Analysis of basic slag—Indian Iron and Steel Co., Burnpur

Ingredients	Per cent
SiO_2	17—21
Al_2O_3	3—4
CaO	45—48
MgO	7— 9
MnO	3·5—5·5
P_2O_5	4·0—5·5
TOTAL Fe	8·5— 11

TABLE 4

Analyses of basic slags—Hindustan Steel Ltd., Rourkela

(Per cent)

Ingredients	O. H. slag	L. D. slag
SiO_2	18—20	15—19
FeO	10·5—15	12·5—18
MnO	8—12	7—12
CaO	43—46	48—52
MgO	5— 7	3— 5
P_2O_5	2·1—2·6	2— 3

TABLE 5

Analyses of basic slags—Hindustan Steel Ltd., Bhilai

(Per cent)

Ingredients	Flushing	Tapping
SiO_2	22—27	15—18
FeO	15—25	7—12
Fe_2O_3	2— 5	2— 5
Al_2O_3	5— 6	5— 6
CaO	21—28	38—46
MgO	6— 9	10—15
MnO	7— 9	4— 6
P_2O_5	3— 5	2— 3

TABLE 6

Analysis of basic slag—Hindustan Steel Ltd., Durgapur

Ingredient	Per cent
P_2O_5	2— 4

TABLE 7

Analysis of basic slag—Mysore Iron and Steel Works, Bhadravati.

Ingredients	Per cent
SiO_2	15—28
FeO	7—16
MnO	4—19
CaO	32—44

Availability of Indian basic slag

The total quantity of basic slag available annually in the country is as follows:—

TABLE 8

Tata Iron and Steel Co. Ltd., Jamshedpur

(In tonnes)

Steel melting shop No. 1	No. 2	No. 3
15,240	63,500	106,680

Indian Iron and Steel Co., Burnpur

100,000—125,000 tonnes

Hindustan Steel, Rourkela

O.H.	*L.D.*
35,000 tonnes	144,000 tonnes

Hindustan Steel, Bhilai

210,000 tonnes at a production rate of 1 million tonnes of ingot steel. About 80 per cent of the total slag consists of flushing slag and the rest tapping slag.

Hindustan Steel, Durgapur

140,000 tonnes

Mysore Iron and Steel, Bhudravati

2,500—3,000 tonnes

Cost :

The cost of granulated slag is estimated at Rs. 7 per tonne f.o.r. steel works.

The by-products of blast furnace slag as also basic slag of the iron and steel industries differ radically from most other liming materials in that their calcium and magnesium are present as silicates and not as carbonates or oxides as in limestone or quick-lime. They contain both calcium and magnesium. It is desirable to make basic slag available in the desired finely ground as well as granulated form in order that it may be effective as a phosphatic fertiliser and as an amendment for acid soils.

In view of the low phosphate content of Indian basic slag, although samples have been tried by various parties at different times for producing fertilisers yet no party has so far reported that it has been possible to produce fertilisers from Indian basic slag on an economic or commercial scale.

In view of the usefulness of basic slag for conditioning acid soils the Government of India had been considering as to whether some concession might be given for encouraging its use in areas that need it. The prevailing railway freight rates on transport of this material which have an important bearing in increasing country's food production are too high and consequently the farmers have not been able to make large scale use of this valuable soil conditioner in agriculture. The matter was, therefore, taken up with the Ministry of Railways for granting concession in conditioning acid soils for agricultural purposes. That Ministry has now agreed to the introduction of special rates equal to class 27.5A for basic slags intended for conditioning of acid soils booked from stations where steel mills are situated to stations where they are required. The special rates are applicable subject to the following conditions :—

(i) The sender must declare on the forwarding note that the consignment is intended for conditioning of acid soils.

(ii) A certificate from the District Agricultural Officer of the district in which the destination station is situated to the effect that the consignment is intended for conditioning of acid soils should be produced for each consignment at the time of booking.

(iii) The special rates will apply subject to a minimum weight for charge equal to the carrying capacity of the wagon used.

(iv) Loading and unloading should be performed by consigners and consignees respectively.

The experiments carried out under Indian conditions particularly at the Sheila Dhar Institute of Soil Science, Allahabad, with Indian basic slags which are poor in P_2O_5 have been found profitable both in nitrogen fixation and in composting. It has also been found that a mixture of organic matter, including coal along with basic soil, improved alkali land considerably.

It is sugested that—

(1) the possibilities of using basic slag for the purpose of conditioning acid soils and also for supplying phosphate to soils in conjunction with organic matter may be examined;

(2) that the matter of making basic slag available in desired finely ground form be taken up by the Ministry of Food and Agriculture with the Ministry of Steel and Heavy Industries (Department of Iron and Steel), so that this valuable material which is lying waste at present, may be used in increasing our agricultural production. If basic slag can be made available in finely ground form at a cheap rate and if the concession in railway freight for its transport is enjoyed by the farmers, it is most likely that the demand for this material will increase in no time and the chances of conditioning large areas of acid soils will be better than ever before. The annexed map shows the distribution of acid soils in the country where this material may be used as a soil conditioner and also as a phosphatic manure; and

(3) the possibility of enriching basic slag in its content of P_2O_5 by mixing the molten material with indigenous rock phosphate may also be explored.

XII. BY-PRODUCTS OF COAL CARBONISATION

High or low temperature carbonisation of coal is carried out primarily for producing hard or soft coke. Hard coke is required in iron and steel making and in other metallurgical and chemical industries such as synthetic ammonia, calcium carbide, etc. Soft coke is required as domestic fuel.

By-products of coal carbonisation are crude benzol, ammonia, coal tar and coke oven gas. Crude benzol is further rectified into various products such as benzene, toluene, solvent naphtha etc. and coal tar is distilled to obtain various oxygenic chemicals namely, phenols, cresols, naphthalene, anthracene and others.

By the end of the Second Plan period high temperature carbonisation of coal had reached a capacity of 11.1 million tonnes of coal throughout. The corresponding production of hard coke was estimated at 8.3 million tonnes. Recovery of by-products was practised to a limited extent depending on the demand for various products.

There was, however, no organised unit for low temperature carbonisation, but about 1.8 million tonnes of soft coke were being produced annually by the wasteful stack burning process.

Production of by-products of coal carbonisation in India during 1956—62 is given on the next page.

TABLE 1

Production of by-products of coal carbonisation

Product	Unit	1956	1957	1958	1959	1960	1961	1962 (Jan.-June)
Benzene	000 litres	1,560	2,350	3,590	4,910	5,360	9,730	2,914
Toluene	,,	3,140	2,410	1,860	820	1,110	860	718
Motor benzol..	,,	3,330	5,610	4,110	3,340	3,920	2,120	1,787
Solvent naphtha	,,	280	420	450	460	480	530	236
Creosote oil	Tonnes	6,790	6,180	4,430	4,890	7,550	3,540	1,840
Road tar	,,	39,480	27,430	20,170	20,170	22,000	20,000	8,970
Pitch	,,	3,760	4,330	4,670	6,160	5,350	19,160	6,340
Naphthalene (refined) ..	,,	970	830	710	660	600	710	540

The production of by-products of coal corbonisation which depends on the existing demand for various products, fell short of full production capacity as is evident from following table:

TABLE 2

By-products of coal carbonisation—capacity and production

Product	Unit	1959		1960		1961	
		Capacity	Production	Capacity	Production	Capacity	Production
Coal tar (crude)	000 tonnes	315	183	369	224	442	244
Naphthalene (refined)	tonnes	1,455	660	1,588	600	1,588	710
Benzene	'000 litres	6,073	4,910	7,333	5,360	32,000	9,730
Toluene	,,	2,728	820	3,213	1,110	8,000	860
Motor benzol	,,	10,410	3,340	11,144	3,920	16,850	2,120

Imports and exports of some of the principal products of coal carbonisation and coal tar distillation from 1957 to 1961-62 are given in the following tables:

TABLE 3

Imports of coal carbonisation by-products

Product	Unit	1957	1958	1959	1960-61	1961-62
Coal tar pitch	Tonnes	5,809	80	30	2,226	1,648
Cresylic acid	,,	608	603	1,093	533	1,552
Oil creosote	Litres	200	13,700	996,700	420	1,128
Pyridine	Tonnes	164	242	271	228	416
Phenol	,,	832	931	1,057	2,062	2,216
Solvent naphtha	Litres	367,800	327,200	302,100	306,100	242,900

TABLE 4

Exports of coal carbonisation by-products

Product	Unit	1957	1958	1959	1960-61	1961-62
Coal tar	Tonnes	1,428	—	417	3,100	2,654
Coal tar pitch	,,	265	203	331	133	4,175
Oil creosote	Litres	367,467	323,296	—	—	—

Exports in comparison to imports are very small.

Against the above pattern of production, exports and imports, the projected demand for some of the products of coal carbonisation as formulated by the Planning Commission is given below :—

TABLE 5

Demand for by-products of coal carbonisation in 1965-66

Product	Estimated demand in 1965-66 (tonnes)
Benzene	52,800
Naphthalene	15,700
Phenol	14,700
Phthalic anhydride	10,200
Road tar	638,000

Production potential of benzene, naphthalene and phenol of by-product origin after expansion during Third Plan has been calculated at 49,360; 15,400 and 6,030 tonnes respectively.

A Committee on By-Products of Coal Carbonisation was set up early in 1960 by the Ministry of Commerce and Industry with the following terms of reference :

(i) to assess the potential availability of the principal by-products of coal carbonisation in the Third Plan;

(ii) to recommend steps that should be taken to ensure the increased utilisation of these by-products;

(iii) to examine, where necessary, the production costs and recommend fair selling prices, particularly for benezene, toluene, xylene and naphthalene; and

(iv) to make any other recommendation that the Committee may deem appropriate having regard to the objective of increasing the utilisation of by-products of coal carbonisation.

The Committee collected a large volume of data, met and discussed with people interested in the subject and visited various coke oven plants. It has recently submitted its report to the Government.

The Third Plan target of steel production is about 10 million tonnes which will require roughly 10 million tonnes of sized hard coke. The demand for hard coke for other industries is expected to be about 2 million tonnes. Thus, the total requirement of hard coke by the end of Third Plan is estimated at 12 million tonnes by the Committee. Of this, about 0.5 million tonnes will be produced by merchant cokeries and in bee-hive coke-ovens without recovery of by-products. The balance of about 11.5 million tonnes of coke will have to be produced in by-product coke ovens from about 17 million tonnes of coal. The Committee has, therefore, based its calculation of by-products potential on 17 million tonnes of coal.

(i) *Crude coal tar.*—A total quantity of 510,000 tonnes of coal tar can be obtained from 17 million tonnes of coal on the basis of 3 per cent yield.

(ii) *Crude benzol.*—From the data collected, the Committee found that recovery of crude benzol varies from 6.0 to 11.5 litres per tonne of coal from plant to plant. It is, however, felt that an average recovery of 10 litres per tonne should be possible. On this basis, about 170 million litres of crude benzol should be available by 1965-66. The Committee has assumed that 85 per cent of this potential can be achieved and, therefore, about 145 million litres of crude benzol would be available for further processing.

(iii) *Benzene and toluene.*—The Committee found that percentage recovery of benzene and toluene varied considerably in practice, but felt that a recovery of at least 60 per cent benzene and 15 per cent toluene of crude benzol processed should be possible. On this basis, the availability of benzene and toluene by the end of Third Plan would be about 87 million litres and 22 million litres respectively.

(iv) *Coal tar distillation products.*—The production of coal tar and the quantities available for distillation during 1957—62 are given in the following table :

TABLE 6

Coal tar produced and distilled

Year	Production of crude coal tar ('000 tonnes)	Distillation of tar ('000 tonnes)
1957	110	43
1958	120	35
1959	180	38
1960	223	62
1961	249	110
1962 (Jan-June)	146	59

The coke ovens attached to public sector steel plants have set up their own tar distillation units which have improved the prospects of gradually distilling more and more of tar as the demand for the products grows. The Committee expects that out of about 510,000 tonnes of crude tar produced, about 435,000 tonnes might be available for distillation by 1965-66, which in turn on distillation would give the following products :—

TABLE 7

Output of coal tar distillation products in 1965-66

	Yield (per cent)	Production (tonnes)
Tar oils	22·5	97,875
Tar acids	2·0	8,700
Tar bases	1·5	6,525
Naphthalene (hot pressed)	4	17,400
Anthracene (crude)	5	21,750
Pitch	60	261,000
Loss	5	21,750
Total	100	435,000

However, the present capacity for coal tar distillation is only 287,800 tonnes; 209,500 tonnes in the public sector and 78,300 tonnes in the private sector as is indicated in the following table. The steel plants in the private sector do not distil any tar. Their entire production of about 125,000 tonnes is used as fuel. The Committee on By-products of Coal Carbonisation felt that it should be practicable to save at least 50,000 tonnes of this tar for distillation. This would be possible by using pitch-creosote and furnace oil as fuel in partial replacement of coal tar. The tar distillation capacity would have to be increased considerably if the demand for tar chemicals increases as anticipated. According to present plans of expansion, the distillation capacity at the end of the Third Plan would be 363,800 tonnes.

TABLE 8

Coal tar production and distillation capacity ('000 tonnes)

Unit	Tar production capacity		Tar distillation capacity	
	At the end of Second Plan	At the end of Third Plan	At the end of Second Plan	At the end of Third Plan
Public Sector				
Sindri Fertilisers and Chemicals Ltd.	11·0	11·0	—	—
Durgapur Coke Ovens (West Bengal Govt.)	15·0	30·0	—	30·0
Rourkela Steel Plant	50·0	75·0	90·0	90·0
Bhilai Steel Plant	44·5	99·0	44·5	44·5
Durgapur Steel Plant	57·0	93·0	75·0	75·0
Neyveli Lignite Project ..	—	46·0	—	46·0
Total ..	177·5	354·0	209·5	285·5
Private Sector				
Bararee Coke Co. Ltd.	1·6	1·6	6·0	6·0
Tata Iron and Steel Co	65·0	65·0	—	—
Indian Iron and Steel Co.. ..	60·0	60·0	—	—
Bhowra Coke Co.	3·6	3·6	3·6	3·6
Bombay Gas Co. Ltd.	2·7	2·7	2·7	2·7
Shalimar Tar Products Ltd. ..	—	—	54·0	54·0
Bengal Chemicals and Pharmaceuticals Ltd.	—	—	12·0	12·0
Total ..	132·9	132·9	78·3	78·3
Grand Total ..	310·4	486·9	287·8	363·8

Probable demand for aromatics derived from coal

The Committee on By-Products of Coal Carbonisation feels that with the expansion of organic chemicals industry during the Third Plan period the demand for by-products, especially for benzene and naphthalene, will increase considerably. It has, therefore, stressed the need for improving the recovery from existing units and also installation of additional capacity for recovery of by-products in the steel plants in the public sector to match with their expansion programmes.

Benzene.—The Committee estimated that the total annual demand for benzene will be 76,500 tonnes or 87 million litres in 1965-66 and 162,000 tonnes or 185 million litres in 1970-71. The Committee felt that with the expansion of organic chemicals industry, the gap between production and demand for benzene and other aromatics will gradually widen and alternate sources e.g. petro-chemicals industry, for these chemicals might have to be explored.

Toluene.—While demand for benzene might exceed production by the end of Third Plan, the demand for toluene would be far short of production. The likely demand for toluene is expected to be 5.41 million litres against the estimated production of 22 million litres. The large surplus of toluene would present a problem of disposal and its utilisation for making phenol might be given some consideration. (The situation has, however, changed after the emergency. The requirements for defence are now estimated at 12 million litres as against 1.82 million litres estimated by the Committee on By-Products of Coal Carbonisation).

Naphthalene.—In India, naphthalene is at present largely used as an insect repellent. But its use as a starting material for organic chemicals industry will be well established in the Third and Fourth Plans. The estimated demand for naphthalene will be 20,000 tonnes by 1965-66 and 40,000 tonnes by 1970-71 as against the estimated production of 14,800 tonnes in 1965-66 assuming that 85 per cent of total potential availability is realised. In this case also the Committee felt that probably by the end of the Third Plan, the demand for naphthalene will outstrip its production and alternate sources for this chemical might have to be explored. The Committee estimated that about 13,000 tonnes of naphthalene will be required for making phthalic anhydride. Recently, the Central Fuel Research Institute, Jealgora has developed a process for making phthalic anhydride from tar oils which has been taken up by the National Research Development Corporation for pilot plant trials. In case the process proves economically feasible, the demand for naphthalene for phthalic anhydride may reduce substantially.

The Committee visualised the following pattern of consumption of tar oils, crude anthracene and pitch, all of which are likely to be in considerable surplus :

TABLE 9

Consumption pattern of tar oils, crude anthracene and pitch

(tonnes)

Purpose	Tar oils	Crude anthracene	Pitch
1. As wash oil for benzol recovery in the coke ovens	10,000	—	—
2. for timber preservation (railway sleepers)	10,000	—	—
3. Pitch-creosote fuel for steel making to replace coal tar	50,000	—	117,000
4. for making carbon black	—	21,750	—
5. for making road tar..	12,000	—	40,000
6. for making low ash coke for aluminium and calcium cabide industries	—	—	100,000
7. Others	15,875	—	4,000
Total ..	97,875	21,750	261,000

The total potential availability of tar acids, at two per cent recovery, from 435,000 tonnes of coal tar distilled, by 1965-66 would be about 8,700 tonnes. As against this level of production, the estimated demand for phenol alone would be 17,000 tonnes by that time. As such, most of the requirements would have to be met by synthetic phenol. The existing capacity for production of pure tar acids is about 1,350 tonnes per annum in Rourkela steel plant. The Neyveli Lignite Project, when it comes into full production, will produce about 3,830 tonnes of pure tar acids. In addition, the Durgapur Coke Ovens will also have facilities for tar acids recovery and purification. The Committee suggested that all public sector steel plants and other tar distillation units to be set up in future should have similar facilities.

Tar bases which have recently been found useful for certain purposes can also be recovered from tar during distillation. From 435,000 tonnes of coal tar about 6,525 tonnes of tar bases can be recovered at 1.5 per cent recovery. Of these bases, gamma-picoline is required for the manufacture of isoniazid, an anti-tubercular drug.

After detailed analysis of the data collected, the Committee on By-Products of Coal Carbonisation has arrived at a number of conclusions and has made certain recommendations. One of the recommendations is concerned with the quality of benzene produced, which is not considered suitable for organic chemicals industry due to high sulphur content. The Committee suggested that all units producing pure benzene from crude benzol should be equipped with hydro-refining facility which is the most recent method of refining benzene and which reduces its sulphur content to the level not considered deleterious for organic synthesis.

Low temperature carbonisation

As already stated, there is as yet no organised unit for production of domestic coke. About 2.5 million tonnes of coal, mostly of grade II quality, are burnt annually in stacks to produce about 1.8 million tonnes of soft coke. Besides soft coke that can be utilised for domestic purposes or in the low shaft furnaces, valuable by-products which can be obtained are :

TABLE 10

Production potential of by-products from low temperature coal carbonisation

	Tonnes per year	Value (Rs. lakhs)
Motor benzol	14,600	28·0
Heavy diesel oil	40,640	80·0
Fuel oil	40,640	48·0
Cresylic acid	20,320	50·0
Phenol	4,060	20·0
Road tar	81,280	160·0

(Calculated from figures given in the Report of the Experts Committee on Synthetic Oil appointed by the Government of India in 1956 under the chairmanship of late Dr. J. C. Ghosh).

The programme of industrial development during the Third Plan includes three projects in the public sector for the production of soft coke with recovery of by-products, in addition to the Neyveli lignite project which would produce about 386,000 tonnes of carbonised briquettes for domestic consumption. These plants to be operated by the respective State Governments will be located at Jambad (West Bengal), Kothagudiam (Andhra Pradesh) and Karanpura (Bihar), with a combined capacity of 2.24 million tonnes of coal throughout.

XIII. SALT BITTERNS

Availability of chemicals from salt bitterns

The present production of common salt in India is about 3.6 million tons. Of this, 3.3 million tons are produced from sea water and sub-soil brine and 0.3 million tons from lake brines. Gujarat State alone produces 50 per cent of salt from sea water and sub-soil brine.

Potassium chloride, magnesium sulphate, magnesium chloride and bromine can be recovered as by-products from the bitterns of marine salt works. The magnesium salts in marine bitterns can also be converted into magnesium oxide or basic magnesium carbonate to be used for industrial purposes. The by-products that can be recovered from the bitterns of Sambhar lake salt works are sodium sulphate and sodium carbonate—both valuable chemicals.

The quantities of chemicals associated with marine and lake bitterns, on the basis of the present production of salt, are given in the table below :—

TABLE 1

Production potential of chemicals from salt bitterns

(tons)

	Marine bitterns	Lake bitterns
Sodium chloride	400,000	40,000
Potassium chloride	50,000	—
Maguesium chloride	400,000	—
Magnesium sulphate	300,000	—
Bromine	16,000	—
Sodium sulphate	—	13,000
Sodium carbonate	—	8,000

In marine salt works, before the crystallisation of salts, gypsum is deposited in the beds. It is estimated that 180,000 tons of gypsum can be recovered annually. At present, only the bigger salt works are recovering gypsum and it is being used mostly in cement factories.

Present status of by-products recovery

So far as marine bitterns are concerned, excepting for some attempts by Tata Chemicals Ltd. at Mithapur, recovery of by-products has not received the attention it deserves in this country. The position in regard to the requirements and imports of the chemicals that can be produced from bitterns is given in Appendix I.

At present there is very little demand for magnesium chloride and magnesium sulphate. With the setting up of the fertiliser factory at

Trombay about 29,000 tons of magnesium sulphate would be required annually. To meet this demand the production of this chemical would have to be undertaken on a large scale in order to avoid its import. The growth of photographic industry and the manufacture of ethylene dibromide both necessitate the production of bromine on a large scale. At present this chemical is being imported, although a small quantity (about 150 tons) of bromine is being produced from salt bitterns by Tata Chemicals Ltd., Mithapur, but when the bitterns are diluted by heavy monsoons some imports to fill the gap are required.

The increasing use of oxy-chloride cement (Sorel cement) flooring in the building industry should find a good outlet for large quantities of magnesium chloride. This would not only give a better and cheaper flooring for residential and office buildings but relieve the pressure of demand for cement to some extent.

The exploitation of marine bitterns should be regarded as a national necessity from the view point of providing the country with potassium chloride, the much-needed potash fertiliser. It is envisaged that the production of common salt will have to go up by at least 100 per cent to meet the demands of industries in the next few years. The amount of bitterns that would be available with this expected increase in the volume of salt production may be adequate for the production of only a portion of potassium chloride that the country needs. There is thus no fear of over-production of potassium chloride.

Investigations at the Central Salt and Marine Chemicals Research Institute, Bhavnagar

The Central Salt and Marine Chemicals Research Institute has been carrying out investigations on the recovery of different by-products from bitterns and has evolved processes for their recovery. Several of these processes have been tested on pilot plant scale and have proved to be economically feasible. Semi-commercial units are to be set up at Kandla and Tuticorin by the Council of Scientific and Industrial Research and the State Trading Corporation.

By-products from Sambhar lake bitterns

This subject has been drawing the attention of the Government of India for at least two decades. The difficulties involved in the separation of sodium sulphate and sodium carbonate were solved by the Central Salt and Marine Chemicals Research Institute by Phase Rule studies of the systems involved. The process evolved on this basis was subjected to pilot plant studies and a scheme for the production of sodium sulphate at Sambhar was entrusted to the Council of Scientific and Industrial Research. The Council sanctioned the setting up of a commercial unit at Sambhar for the purpose. The project did not materialise because of the high cost of electricity at Sambhar. Even assuming 10 nP. per kilowatt-hour as the cost of electricity the process would yield sodium sulphate at Rs. 150 per ton, while the selling price is about double this amount. It is understood that the Hindustan Salt Company have a project in hand to put up a washery-*cum*-by-product recovery plant at Sambhar.

Marine bitterns

The Central Salt and Marine Chemicals Research Institute has evolved three distinct processes for the exploitation of marine bitterns. The processes, which have been tested on pilot plant scale and proved to be economically feasible, are :

I. A process for the recovery of potassium chloride and magnesium sulphate;

II. A process for the production of potassium chloride, sodium sulphate and magnesium sulphate.

III. A process for the production of potassium chloride, sodium sulphate and magnesium carbonate.

Project reports for all these processes are ready for release to the industry.

The Council of Scientific and Industrial Research is putting up a semi-commercial unit at Kandla for the production of potassium chloride and magnesium sulphate by process (I).

The Central Salt and Marine Chemicals Research Institute has given a project report for the exploitation of mixed salts, which are obtained by the solar evaporation of bitterns based on process (II), to the State Trading Corporation for the production of potassium chloride, sodium sulphate and magnesium sulphate. A semi-commercial unit is to be set up at Tuticorin for this purpose.

A project report for process (III) is about to be released to a Bombay firm.

All these three processes are highly remunerative. The table in Appendix II gives details regarding these processes and investments needed for economic units and returns.

The salt bitterns now available as waste are concentrated in the coastal regions of Gujarat and south-eastern Madras having a large number of salt factories. There are, however, only a few salt producers who can mobilise substantial quantities of salt bitterns for commercial exploitation. It would, therefore, be necessary to set up an industry for recovery of chemicals with the co-operation of all salt producers in the region, so that a unit of economic size for the recovery of marine chemicals available as by-products is established. It is also considered necessary to undertake a survey of the total availability of bitterns in different regions with a view to deciding on the location of such a project. Kandla, Jamnagar, Bhavnagar, Tuticorin are some of the places which can be considered for this project.

APPENDIX I

Requirements, production and imports of chemicals which can be produced from salt bitterns

Chemical	Present requirement	Present production	Present production capacity	Requirement by the end of Third Plan	Imports, if any, and their value	Factories utilizing sea bitterns	Uses of the product
(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
1. Potassium chloride	75,000 tons	Insignificant	Not known	250,000 tons	52,544 tons Rs.1,31,84,331	Tata Chemicals Ltd., Mithapur (capacity not known)	Fertiliser, potassium chlorate and other potassium salts.
2. Light basic magnesium carbonate	2,500 tons	18 tons	1,320 tons (2 units)	Not known	1,100 tons Rs. 10·25 lakhs (1959)	Pioneer Magnesia Works, Kharaghoda. (capacity not known)	Rubber, insulation, paper and paints.
3. Magnesium sulphate.	2,500 tons (12,000 tons would be required by the Trombay fertiliser factory)	3,800 tons (only 600 tons from bitterns, balance from magnesite and sulphuric acid)	7,900 tons (15 units) (1,500 tons from bitterns)	Not known	Nil	(1) Tata Chemicals Ltd., Mithapur. (2) Pioneer Magnesia Works, Kharaghoda. (3) Mettur Chemicals, Mettur.	Fertilizer, paper, textiles, fire-proofing compounds, pharmaceuticals.
4. Magnesium chloride	Not available	7,500 tons	39,600 tons (4 units)	Not known	Nil	(1) Tata Chemicals Ltd., Mithapur. (2) Pioneer Magnesia Works, Kharaghoda. (3) Mayurdhwaj Magnesia Works, Kuda.	Textiles, oxychloride cement, fire-proofing.

(1)	(2)	(3)	(4)	(5)	(6)	(7)	(8)
5. Sodium sulphate	40,000 tons	20,000 tons*	21,600 tons (19 units)	Not known	18,000 tons Rs. 45 lakhs (1959)	Nil	Paper, glass, textiles.
6. Calcium sulphate	4,000 tons (by the marine process)	Not known			Not known		Portland cement, pencils and plaster material.

*By-product from rayon factories.

APPENDIX II

Processes, investment requirements and returns on investment worked out by the Central Salt and Marine Chemicals Research Institute

Process	Capacity of economic unit	Investment required (Rupees)	Annual return on investment (per cent)
1. Manufacture of light magnesium carbonate	2 tons per 16 hours per 250 days per year	3,73,000	42·2
2. Manufacture of potassium chloride and epsom salt from mixed salt	3 tons/24 hours	6,40,000	48·0
3. Manufacture of oxychloride cement (Sorel cement) flooring tiles.	2,200 tiles per day	2,30,000	41·5
4. Manufacture of potassium chloride, magnesium sulphate and sodium sulphate from mixed salt	Potassium chloride, 2 tons/16 hours/300 days per year Epsom salt, 4·8 tons/16 hours/300 days per year	8,91,000	58·0
5. Manufacture of basic magnesium carbonate, potassium chloride and sodium sulphate from mixed salt	3 tons basic magnesium carbonate, 2·1 tons sodium sulphate, 1·95 tons potassium chloride and 3 tons table salt per day of 24 hours	14,21,000	22·8
6. Manufacture of table salt	1 ton/8 hours/300 days/year	1,43,000	24·2
7. Manufacture of dairy salt	1 ton/8 hours/300 days/year	1,42,000	22·6
8. Manufacture of cattle licks	100 cattle licks/8 hours/200 days/year	9,500	48·0

XIV COAL ASH

Introduction

With the growth of industrialisation visualised in the successive Five Year Plans, the demand for coal, our chief industrial fuel, will be on an ever-increasing scale. The present production of about 60 million tons of coal per annum will be stepped up to about 250 million tons by 1975-76. To meet this demand, we will have to rely mainly on our extensive deposits of inferior coals. In addition, the demand for metallurgical coke, conforming to stringent specifications, by the iron and steel industry has given rise to the necessity to wash coal, for which the Government is setting up a number of Central washeries. These will produce large quantities of high-ash by-product fuels in the form of middlings and rejects. By-products of washeries and other high ash coals will, therefore, have to be increasingly used as sources of energy for industry. Besides giving rise to technological problems of designing boilers etc. to use low grade coals, this would raise the problem of handling and disposing of ash.

Coal ash is the residue left after burning coal and consists mostly of fine fractions. Depending upon the form in which the coal is used, it is classified further as cinder (or clinker) and fly ash.

Cinder (or clinker).—When lump coal is used for raising steam in boilers, the furnace residue, which has been fused in lumps of varying sizes, is called cinder or clinker. Its total production is about 3½ million tons per year. The major sources are the railways and the thermal power stations using lump coal.

Fly ash.—This is the finely divided residue that results from the combustion of pulverised coal in the boiler. It is carried away from the boiler by flue gases and collected by means of electrical or mechanical precipitators. Its production, which at present is about 1½ million tons per year, is expected to rise to about 3½ million tons per year by the end of the Third Five Year Plan, as a number of thermal power stations, which would utilise pulverised coal middlings from the washeries, are expected to be commissioned during the period.

Wet bottom, pulverised fuel furnaces and slagging ash gasifiers produce ash in the molten form. The disposal or utilisation of this used to be a troublesome and costly business till it was realised that there were a number of uses for which it was admirably suitable.

Methods of utilisation

Coal ash has been utilised in several ways depending upon its chemical composition, content of unburnt fuel, fineness, density, etc. The following uses are important :

(a) In the manufacture of pozzolanic cement.

(b) As a lightweight aggregate for use in concrete, concrete blocks or slabs, etc.
(c) In masonry mortars.
(d) In making bricks from black cotton or similar clayey soils.
(e) In making fly ash cinder bricks.
(f) In making aerated concrete.

In the manufacture of pozzolanic cement

The investigations carried out at the Central Building Research Institute, Roorkee, and the Railway Testing and Research Centre, Lucknow, have shown that (i) Indian fly ashes (samples collected from Bokaro, Durgapur, Kanpur and Madras) are good pozzolanas and can replace cement up to 20 per cent. Though the strengths obtained are lower than the strength obtained without replacement in 1 : 3 cement-sand mortar, it is more than the specified limit of 80 per cent in 28 days. Fly ashes from Kanpur and Madras, however, contain a high amount of unburnt fuel and should, therefore, be used either after fractionation or in replacement of less than 20 per cent; and (ii) finely ground loco coal ash having unburnt fuel up to 15 per cent can be used to replace 20 per cent of cement in plain concrete.

As lightweight aggregate for use in concrete, concrete blocks or slabs, etc.

The use of coal ash and fly ash in the manufacture of pozzolanic cement, though quite advantageous, does not go a long way towards solving the problem of utilisation as the quantities utilised are small. The use of these materials as light-weight aggregates in concrete, concrete blocks, slabs, etc. is the most important application as large quantities of ash can be utilised in this way.

Railways, which are at present the biggest producers of coal ash or cinder, have used this material from time to time in making walling blocks and jack arch roofing elements. Structures built with these units have shown satisfactory performance. While leaner mixes have been suggested, the work done at the Central Building Research Institute has shown that units made with leaner mixes are liable to greater drying shrinkage. A 1 : 6 cement-cinder mix by volume is quite suitable both from the point of view of strength and shrinkage.

At the Central Building Research Institute a sintered lightweight aggregate has been prepared in a pilot sinter plant with the Bokaro and Durgapur fly ashes. The cost of production worked out to be about Rs. 35 per 100 cft.

The unit weights of crushed sintered aggregate and the concrete prepared with it are 55 lbs./cft. and 80 lbs./cft. The aggregate is suitable for making concrete blocks and for *in situ* concrete construction.

A comparison of the cost of cinder concrete block construction with that of brick masonry has shown the former to be more economical at places where bricks are available at Rs. 50 or more per thousand. The cost of concrete blocks made from sintered fly ash aggregate will be a little more than cinder concrete blocks. Blocks made with sintered fly ash aggregate will, however, be lighter and more stable under changing atmospheric conditions and, therefore, more suitable for exposed constructions.

The use of cinder and sintered fly ash aggregate for making concrete blocks, etc. is recommended. The manufacture and use of sintered fly ash aggregate at the thermal power stations and in the surrounding areas, would have the advantages of disposing of the ash, increasing the pace of construction, and reducing the cost of walling in areas where bricks are costly (Rs. 50 or more per thousand).

In masonry mortars

Nowadays coal ash is often used in place of *surkhi* in making lime mortar for masonry construction. The proportions (by volume) generally adopted are 1 : 2, 1 : 3, lime-coal ash, or 1 : 1 : 1, 1 : 1 : 2 lime-coal ash-sand. The mortar is prepared in a way similar to that of lime-*surkhi* mortar.

Compared to cement mortars, lime-coal ash mortars are cheaper. These are better than lime-sand mortars both in strength and performance. Their use for building a two-storeyed house has been found quite suitable.

In making bricks from black cotton or similar clayey soils

Good bricks from black cotton or similar soil cannot be made because of excessive drying shrinkage. Admixtures such as coal ash, fly ash, grog, etc. are known to reduce the drying shrinkage and make such soils more suitable for brick making. Investigations carried out at the Central Building Research Institute have shown that 'A' class bricks can be made from black cotton soil by incorporating finely ground coal ash in equal proportions.

In making fly ash-cinder-cement bricks

Work done at the Central Building Research Institute has shown that good bricks can be prepared by using fly ash, cinder and cement in proportion of 3 : 6 : 1 by weight and pressing the mixture into moulds at about 20 per cent moisture and 20 tons pressure. The manufacture of such bricks at the thermal power stations and particularly in areas, where good quality bricks are either not available or are costly, deserves consideration.

In making aerated concrete

Fly ash has been used in the manufacture of aerated concrete (also known as gas, cellular or foamed concrete) in other countries. Similar use of fly ash for making aerated concrete in India, though not yet made, also deserves consideration.

Availability of coal ash

About 25 million tons or more of coal are being used by the railways and the thermal power stations and the ash produced from these may total about 8 million tons or more per year by 1965. This will increase considerably in the Fourth Plan when the thermal power plant capacities are likely to be more than doubled and the coal used in them will have considerably higher ash content than at present. To this may be added a large amount of rejects from the coal washeries which will, however, have rather high carbon content and cannot be burnt at present. But the production of ash is not localised at a few centres. The power stations are distributed all over the country. In the Appendix are indicated the estimated quantities of ash that are likely to be available from only the large power stations (10 MW or over) which would be utilising high ash coals. In the case of railways the coaling stations are mostly situated about 200-250 kilometers apart at the junctions and some quantities of ash are, therefore, available at these junction stations. The production of ash in the case of railways is rather small and localised compared to the large power stations. In the case of large thermal power stations, fairly large quantities of ash would be available locally and would consist largely of inorganic residue of mineral matter in coal with very little unburnt organic matter. This will not be so in the case of cinders from the locomotive engines, which consist of large quantities of unburnt carbonaceous matter, besides the inorganic residue of mineral matter in coal.

Since the coal ash from the railways is available in relatively small quantities distributed over a large number of centres the method for utilising it locally should be developed. The cost of collection and transportation may make their utilisation elsewhere wholly uneconomic.

Exploitation of railway loco cinders can possibly be best done by railways themselves, whereas other agencies can possibly be established for exploitation of coal ash from power stations.

Since the power stations do not keep to a constant source of coal, the data on composition and quality of cinder or fly ash are scanty. A survey may be necessary in due course.

The table below shows a great variation in the composition of coal ash from different fields. Some of the ashes, especially of Madhya Pradesh and Bokaro-Karanpura fields, are highly refractory in character. Doping with fluxes has to be adopted for getting slag of suitable composition. The ash of meta-anthracite in Rhode Island is also comparatively refractory, but doping with dolomitic limestone has resulted in the production of slag of high fluidity to enable the making of slag wool. The same technique can also be used for the refractory Indian coal ashes. Further, coal ash slags may find use in making slag cement and in the building industry. Cinders with tolerable combustible matter (less than 3 per cent) may be used in making concrete masonry blocks. The proposed outlets for the disposal of the waste materials need extensive experimental tests.

TABLE

Composition of coal ashes from major coal fields

	Jharia	Raniganj	Madhya Pradesh	Bokaro-Karan-pura
SiO_2	45—60	40—55	50—70	50—60
Al_2O_3	20—33	16—35	20—30	25—40
Fe_2O_3	2—12	5—18	2—7	5—14
TiO_2	1·5—3·0	1—2·5	1·5—3·0	1·5—3·0
P_2O_5	0·3—5·0	0·5—2·5	0·1—1·0	0·5—2·5
CaO	2—7	2·5—10·0	0·2—3·0	0·5—3·0
MgO	1—3	1—3	0·5—1·5	0·5—1·0
SO_3	0·5—4·0	0·5—4·5	0·5—2·5	0·1—0·5
Alkalis	0·2—3·0	0·4—4·0	0·5—2·0	0-5—3·0

Conclusion

In the light of the above study about the nature of fly ash and coal ash in India, it can be said that the economic disposal of a large amount of these waste materials will bring a saving in the total cost of coal used. Trials should be conducted firstly to assess the quality of the raw materials, secondly, the possible uses they may be put to and thirdly, the economics of such utilisation.

APPENDIX

Estimated quantities of ash likely to be available from large steam power stations by 1965-66 (power plants with 10 MW and above sets have only been mentioned)

Location of steam plant	Installed capacity by 1965-66 (MW)	Net amount of ash available per annum by 1965-66 (In thousand tons)
(1)	(2)	(3)
West Bengal		
1. Calcutta		
(*i*) Cossipore	67·50	73.0
(*ii*) Mulajore	150·00	162.0
(*iii*) New Cossipore	110·00	119·0
(*iv*) Southern Power Station	80·00	86.0
2. Halishahar, Naihati	28·75	31·0
3. Durgapur Coke Oven Power Station*	150·00	189·0
4. Bandel Power Station	300·00	378·0
5. Durgapur, D.V.C.*	165·00	208·0
Bihar		
6. Bokaro*	255·00	321·0
7. Barauni	105·00	132·0
8. Patratu*	350·00	441·0
9. Chandrapura*	280·00	353·0
Orissa		
11. Talcher	240·00	302·0
Madhya Pradesh		
12. Korba	290·00	365·0
13. Satpura	180·00	227·0
14. Amarkantak	60·00	76·0
15. Singrauli	250·00	315·0
Uttar Pradesh		
16. Harduaganj	90·00	113·0
17. Kanpur	72·50	78.0
Delhi		
18. Delhi A & B Power Stations	210·00	227·0
Rajasthan		
19. Thermal Extn. Rajasthan	90·00	97·0
Maharashtra and Gujarat		
20. Chola	118·00	128·0
21. Sabarmati B & C, Ahmedabad	180·00	194·0
22. Tata P. P. S.	187·50	203·0
23. Duvaran (Cambay)	200·00	252·0
24. Akola (Paras)	90·00	113·0
25. Khaparkheda	120·00	152·0
26. Bhusawal	60·00	76·0

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(1)	(2)	(3)
Andhra Pradesh		
27. Nellore	30·00	32·0
28. Ramgundam	97·50	123·0
29. Kothagudium	120·00	151·0
Madras		
30. Madurai	10·00	11·0
31. Basin Bridge, Madras	87·00	95·0
Jammu and Kashmir		
32. Kalakot	20·00	22·0

*These plants are in DVC area.

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XV. MICA WASTE

India is the principal producer of mica and has a near monopoly in the mica trade, accounting for over 80 per cent of the total world supply of the material. Other producing countries are Brazil, Madagascar, U.S.A., Tanganyika, and Southern Rhodesia. In India, the principal mica bearing mines are located in Bihar, Rajasthan and Andhra Pradesh. In 1960, Bihar accounted for 50.1 per cent, Rajasthan 25.1 per cent, and Andhra Pradesh 24.0 per cent of the total output of crude mica in India. The remainder came in small parcels from Madras and Kerala.

In Bihar, the mica belt extends from Gaya in the West for some 90 miles, through Hazaribagh and Monghyr, to Bhagalpur in the east with a width of 12-16 miles. The most productive mines lie in and around Kodarma reserved forest in Hazaribagh District. In Rajasthan, the mica belt covers an area some 60 miles wide stretching from Jaipur in the north-east for more than 200 miles into Udaipur in the south-west. Bhilwara is the most important producing district in Rajasthan. In Andhra Pradesh, the mica belt stretches for some 60 miles between Gudur and Sangam with a width of 8–10 miles in the Nellore District. Important mines are located near Gudur, Rapur, Podalakur, Atmakur and Kavali, of which Rapur is the leading centre. Ruby mica which has long been considered as the best quality of mica is won from the Bihar mines. Rajasthan yields stained ruby, green and other varieties of mica. Andhra Pradesh produces mostly green and black stained varieties.

Mica owes its importance to a unique combination of physical, chemical, thermal and dielectric properties which make it almost irreplaceable by any natural or synthetic product, especially in the electrical industry. The most important physical property responsible for the growth of mica splitting industry is its perfect basal cleavage. This property enables it to lend itself to easy and accurate splitting into thin sheets or films of any specified thickness. The perfection of its laminate structure can be appreciated from the fact that it can be split into flexible and transparent films as thin as 0.00025 inch.

The two important industrial micas are muscovite, also known as white mica (potassium aluminium silicate) which can withstand a temperature of about 700°C. and phlogopite or amber mica (magnesium aluminium silicate) which does not undergo any structural change even at temperatures as high as 900°C.

Mica obtained from the mine is in crude form, mixed with pegmatite materials. The preliminary dressing of mica in the mine (cobbing) frees mica block from dirt and waste as well as defective material such as rough, buckled, wrinkled and wavy mica and only commercially sound mica is retained. The rough cobbed mica is then rifted or split into thin sheets 1/8, 1/16 or 1/32 inch thick or still less. Loose bits or torn or frayed edges are also removed. The equipments used are very simple consisting only of a wooden peg, a sickle and a knife. This is, however, a highly specialised job and Indian splitters and trimmers have achieved world-wide fame. After splitting, the small sizes are screened over different meshes before final packing. The ultimate coversion of the mica block, splittings etc. is undertaken normally by the consuming countries.

Mica with its low thermal conductivity and high dielectric strength, toughness, flexibility, resistance to temperature changes and chemical decomposition and comparatively high heat resistance is mostly used in the electrical industry for insulation purposes. Ground mica is used in chemical and paint industry. Wet ground mica is used as a filler and as a mould lubricant in rubber manufacture and some plastics. It is also used in the manufacture of roofing material, welding rods, wall paper, lamp chimneys, shades etc.,

Though India is the leading producer of mica, home consumption of the same has not developed to any appreciable extent and practically the whole of saleable mica produced in the country is exported. Of course, with the development of electrical industries in the successive Five Year Plans, the domestic consumption of mica is expected to increase substantially. The exports in 1960-61 and 1961-62 are given below :

TABLE 1

Exports of mica during 1960-61 *and* 1961-62

	1960-61		1961-62	
	Quantity (tons)	Value (Rs. in lakhs)	Quantity (tons)	Value (Rs. in lakhs)
Blocks	2,248	4,13	2,087	4,03
Splittings	8,053	5,79	8,030	5,38
Others (ground, waste, scrap, etc.)	17,642	23	17,575	25
TOTAL ..	27,943	10,15	27,692	9,66

The world production of mica is generally divided into two categories *viz.* (i) sheet mica which includes blocks, films and splittings and (ii) waste and scrap mica comprising the bulk of the total output. All mica, exclusive of mica schist, which because of size, colour or quality is below specifications for sheet mica constitutes waste or scrap mica. In India, waste or scrap mica is mainly of muscovite variety obtained from mining, grading, trimming and punching sheet mica and is known in the trade as 'mine scrap' and 'factory scrap'.

In U.S.A., most of the mica mined is of the scrap quality and utilisation of scrap mica is the mainstay of the U.S. mica industry. In fact, it is the only country where extensive research has been undertaken on the utilisation of scrap mica. Practically, the only outlet for mica scrap available in other countries is to export it to U.S.A. at very low prices. As a result of prolonged researches, the demand for mica scrap in the U.S.A. is going up by leaps and bounds. The demand has gone up to such an amazing extent that the large domestic production of scrap, reclaimed and flake mica does not adequately meet the evergrowing demands of the industry and about ten per cent of the requirements are met by imports from India and Africa.

The process of dressing mica leaves a fairly large quantity of waste which usually varies from 80 to 85 per cent of the total mica mined. There is a further loss of about 50—60 per cent during the process of fabrication into various parts. Thus, through the various stages of processing from the mine to its ultimate consumption, a very high percentage of the mine-run is rendered waste or scrap. Such an enormous waste takes place practically in all the mica producing countries as may be seen from the table below :

TABLE 2

Wastage of mica in different countries

Country	Wastage (per cent of total mine-run)
India	85—90
U.S.A.	90—95
Brazil	about 95
East Africa	96—97

A major portion of Indian mica waste is being exported but the rest is being dumped as useless material near the pitheads of the mines. Suggestions have been made to restrict or ban the export of mica waste. It is alleged that the importing countries are advantageously using the waste, which they import at a nominal price, for making built-up mica *e.g.* micanite. It is feared that this would restrict the export of Indian mica splittings which are normally used as raw material for built-up mica.

Availability of waste mica in India.—As already stated, India is the largest producer of mica and the principal supplier of sheet mica to the world. Indian ruby mica holds a unique position in the world list of strategic materials. Production and export of mica from India has been gradually increasing and, therefore, there has been a rapid accumulation of mica waste in the mica fields of Bihar, Rajasthan and Andhra Pradesh. It is estimated that India produces more than 25,000 tons of mica waste every year. In addition, there are unknown quantities of accumulated waste in the mica fields. So, India has got abundant supplies of mica waste.

Utilisation of mica waste.—The utilisation of waste mica which constitutes 85—90 per cent of the total mica mined is a major problem. Investigations have, therefore, been undertaken in a number of research institutions in India to find profitable uses for waste mica. The major contribution in this field has been from the Central Glass and Ceramic Research Institute, Calcutta. A separate mica research unit has recently been established in the Institute which, among other things, undertakes research on the utilisation of mica waste.

Waste or scrap mica is almost invariably used for grinding purposes. Virtually all the present day uses of ground mica depend largely upon its appearance and lubricating properties. Both of these characteristics are affected by the method of grinding as well as the purity and nature of the scrap.

Scrap mica is ground by three processes, namely, dry grinding, wet grinding and micronising. The marketed product is classified according to the grinding process which indicates quality and properties like colour, mesh size and bulk density. Blending of scrap is often necessary in order to produce the desired product.

Quality of scrap.—For industrial utilisation, mica scrap, whether from the mine or factory, is generally of the muscovite or phlogopite variety. As already stated, Indian mica is mostly muscovite, the variety which is more commonly used by the grinding industry, specially in the high quality wet process where whiteness of the product is of prime importance. In order to be suitable for use by the grinders, the scrap must be washed free of clay and mud. Besides, it must have minimum amount of staining and should preferably contain little or no grit. The size of scrap is not of much importance in grinding efficiency. As regards quality, Indian scrap, especially of the ruby or white variety, is at least as good as that of U.S.A.

Properties of ground mica.—When ground to a powder, scrap mica has a unique combination of many useful properties which make it a highly desirable product for many industrial applications. Its ability to retain the flaky structure even after extremely fine grinding provides a high covering power, and its retention of a high lustre after wet grinding provides excellent reflective properties. It possesses good lubricating properties. It is also useful due to its inert, tough and flexible nature and high thermal and electrical insulation values. A host of uses have been developed on the basis of the aforesaid properties.

Uses.—The established uses of ground mica in the U.S.A. are too numerous to be discussed. Most of the wet ground and a considerable amount of high grade dry ground mica is used as paint ingredient. The wall paper industry also consumes an appreciable amount of wet ground mica. Dry ground mica is used mainly in the manufacture of roll roofing sheet, other uses being in making welding rods and in oil-well drilling. Pure grades of both dry and wet ground mica are utilised as inert fillers and dusting powder in the rubber industry. Other uses of mica powder are in the manufacture of plastics, electric cable and telephone wire insulation, artificial snow, axle greases and oils, pipe line enamels, textiles, glass bonded mica, wall board cement, asphalt mats for aircraft landing, house insulation and annealing of steel. The approximate distribution of ground mica to the leading consuming industries in the U.S.A. in 1960 is shown below :

TABLE 3

Ground mica sold for various uses in U.S.A. in 1960

Use	Quantity in tons
Roofing sheet	48,140
Paint	19,645
Wall board cement	11,775
Oil well drilling	9,620
Rubber	8,945
Wall paper	508
Plastics	435
Other uses*	8,390

*Includes mica used as facings for moulds, for electric insulation, Christmas tree snow, annealing of steel, welding rods, etc.

Paint has, of late, been the rapidly growing consumer of ground mica in the U.S.A. and there is also a trend of increased consumption in wall board cement and oilwell drilling mud. Recently, there has been considerable research in U.S.A. and France for utilising mica scrap for manufacturing different types of reconstituted sheet-like mica products *e.g.* samica, mica mat and integrated mica. Such products made by the paper making process and claimed to be more uniform in properties than built-up mica (*e.g.* micanite) are gradually finding extensive uses in the electrical industry.

Research carried out in India and its application.—The possibility of utilising mica waste has engaged the attention of the Central Glass and Ceramic Research Institute which has done considerable research on the subject. The Institute has developed a new application for making heat insulating bricks comparable in properties like bulk density, porosity, thermal conductivity etc. to bricks made out of imported vermiculite and imported diatomite bricks used extensively in industrial furnaces as backing insulation behind a course of refractory bricks. By utilising the researches carried out at the Institute (Indian Patent No. 48667) two factories, one in Rajasthan and the other in Bihar, have been set up for manufacturing mica insulating bricks. These bricks have been used in the Bhilai steel plant and the oil refinery at Gauhati. This research has established a new outlet for mica scrap and has, to an extent, helped to conserve the foreign exchange spent on importing vermiculite and diatomite bricks. It is, however, understood that the Rajasthan factory has not been able to utilise its full capacity for want of orders. The Bihar factory could not start production so far due to the same reason. It appears that the Indian product is costlier and somewhat inferior to the imported vermiculite and diatomite bricks which it is meant to replace. Efforts are being made to improve the quality of the Indian product as also to bring down its cost of production.

Grinding of mica.—When scrap mica is ground by the dry process in high speed hammer mills, the edges of the flakes get crushed and torn and the ground material has the appearance of flour. To produce mica powder with a shiny appearance, wet processes involving preferential delamination of flakes are employed. Chaser mills, with large wheels or rollers rotating on a horizontal shaft, are used for the purpose. A wet grinding process (Indian Patent No. 55454) involving the use of an edge runner mill has been developed in the Central Glass and Ceramic Research Institute. The grinding roller and the mill pan are lined with soft wood. The frictional grinding delaminates mica flakes to fine particles. The product is stated to be comparable in properties and performance to foreign products. This process has not so far been commercially exploited. The domestic consumption of mica powder is rather small to justify the setting up of a factory for its manufacture. However, the Department of Technical Development, Ministry of Economic and Defence Coordination and the National Research Development Corporation have been trying to interest entrepreneurs to manufacture mica powder in India, chiefly as an export-oriented programme.

U.S.A. is the largest producer and consumer of ground mica. Most of the European countries manufacture mica powder from imported Indian scrap. In view of the availability of cheap raw material and labour, India should be able to compete in European and Asian markets for wet ground mica. The chances of her competing in the U.S. market are also fair as has been shown in a study undertaken by the National Council of Applied Economic Research. The Department of Technical Development and the National Research Development Corporation should, therefore, continue their efforts to interest entrepreneurs to set up a factory in India for the manufacture of wet ground mica using the process developed by the Central Glass and Ceramic Research Institute. If no entrepreneur comes forward within a reasonable time, due to shyness to try a new method, the National Research Development Corporation should arrange to try the process on a semi-commercial scale with a view to verify that it produces a material which is acceptable in foreign markets at an economical price.

Utilisation of mica powder.—By using suitable amounts of mica powder of desired fineness as partial substitute for the conventional expensive pigments and extenders, the Central Glass and Ceramic Research Institute has developed paints having appreciably improved corrosion resistance, hardness, weathering resistance, heat resistance, flexibility and resistance to wear and also better storage properties. The use of mica reduces the cost of the paint without having any detrimental effect on finish, drying time, covering power and other desired properties. The Central Glass and Ceramic Research Institute has patented quite a few compositions of mica-bearing paints. In view of their improved properties and reduced cost, there appears to be considerable scope of their application as better substitutes for the various types of conventional paints whose demand has been steadily rising.

Mica-based greases have been developed in the Institute by replacing a very substantial amount (approaching 100 per cent) of graphite and the greases are comparable to graphite greases used extensively by the railways and the automobile industry.

Work has also been done in the Central Glass and Ceramic Research Institute on the development of new products similar to samica of U.S.A. Glass bonded mica suitable for use in the electrical industry has also been developed in the Institute. Mica boards and laminates similar to imported asbestos sheets and boards used extensively by the railways in coaches for heat insulation are under development in the Institute.

The Central Glass and Ceramic Research Institute should continue research in finding new uses for ground mica or mica waste directly and the National Research Development Corporation should give due publicity to results of the research with a view to their adoption in the industries concerned.

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RECOMMENDATIONS

Sl. No.	Recommendations	Action to be taken by
I.	RICE BRAN	
1.	Rice bran extraction plants may preferably be located within a radius of 50 miles from the concentration of rice mills in order to ensure quick and economic transport of this raw material.	State Governments through Deptt. of Technical Development, Ministry of Economic & Defence Co-ordination.
2.	The existing hullers should be modernised into sheller type of rice mills without substantially increasing overall milling capacity.	Do.
3.	The investigation work on the refining, bleaching, deodorisation and hydrogenation of the oil should be carried out in the National Laboratories/Oil Industrial Research Technological Research Institutes.	Council of Scientific and Industrial Research.
4.	As a preliminary to the popularisation of de-oiled rice bran as cattle and poultry feed, research work should be undertaken in the preparation of nutritious compounded cattle feeds and poultry feeds (using de-oiled rice bran) by the India Veterinary Research Institute, Izatnagar (U.P.).	Ministry of Food and Agriculture.
II.	OIL-BEARING TREE; NON-EDIBLE MINOR OILSEEDS	
	(*a*) *Resources survey of non-edible oilseeds*	
1.	Works on the survey and development of non-edible oilseeds might be undertaken in order of the following priorities. *Priority I* : Existing potential resources required to be utilised and further developed. (1) *Madhuca indica* J. F. Gmel & M. *longifolia* (1 inn.) Macbride, Sapotaceae, *Mahua* (2) *Azadirachta indica* A. Juss, Meliaceae, *Neem* (3) *Pongamia pinnata* (Linn.) Merr., *Leguminosao*, *Raranja* (4) Galophyllum inophyllum, Linn, Guttiferae, *Undi* *Priority II* : Existing Potential resources which can be developed largely provided Economical and Technical Problems are Resolved. (1) *Mallotus phibippinensis* Muell. Arg., Euphorbiaceae, *Kamala* (2) Mesua flerrea Linn., Guttiferae, *Nahor* (3) *Actinodaphne hookeri* Meissn., Lauraceae, *Pisa* *Priority III* : Existing Potential Resources available in sizeable quantities but involving problems of economic collection, handling, development, etc.	Indian Central Oilseeds Committee, Khadi and Village Industries Commissions and State Governments.

Sl. No.	Recommendations	to be taken Action by
	(1) *Lantana Camara* Linn, verbenaceae, *Ghangeri* (2) *Salvadora oleoides* Dcne Salvadoraceae, *Khakan* (3) *Garcinia* indica chois. Guttiferae, *Kokum* (4) *Vateria indica*, Linn., Dipterocarpaceae, *Dhupa* (5) *Aleurites montana* & A. fordii, Euphorbiaceae, *Tung.* (6) *Moringa oleifera* Lam. Mornnigacae, *Ben* (7) *Schleichora eleesa* (Lour.) Merr, Sapindaceae, *Kosam* (8) *Madhuca butyracea* (Roxg.) Macbride, Sapotaceae, *Phalwara* butter.	
2.	A model scheme for sample survey of non-edible oilseeds in forest areas with the specific objective to make a survey of the eleven approved species, which offer scope for commercial utilisation may be drawn up.	Indian Central Oilseeds Committee.
3.	Long-range intensive surveys should be taken all over the country with a view to preparing regional and species-wise maps for the availability of various oil-bearing plants in the country. These plants should be based on a statistical plan, so that the data thus collected should be as realistic as possible.	Do.
	(*b*) *Development of plantations*	
1.	The possibility of forming Forest Labour Cooperative Societies, on lines similar to those in Maharashtra State may be examined by other States.	State Forest Departments.
2.	The Forest Departments might undertake the plantation of non-edible oilseed bearing trees like neem, mahua, karanja in their afforestation programme. Some portion of land from the Soil Conservation areas and new irrigation projects could also be set apart for this purpose. The Public Works Department of the States might take up the plantation of neem, mahua and karanja trees on highways.	Forest, Agriculture, and P.W. Departments of States.
3.	Simultaneously, intensive efforts should be made all over the country by selecting suitable species of economic oil-bearing plants to be grown in suitable areas under the care of the Village Panchayats and Community Development Centres. Avenue road-sides, etc., should be planted with such oil-bearing trees.	Do.
4.	The State Government might consider the question of enacting legislation prohibiting the felling of Mahua trees. They might also examine the question of regeneration of Mahua trees in areas where they have been removed. Schemes for distribution of Mahua seeds and seedlings, similar to one sanctioned in Madras State, might be invited from other states. Planting of trees should be in compact blocks in order to facilitate the collection of seeds.	Indian Central Oilseeds Committee, and Stat Governments.

Sl. No.	Recommendations	Action to be taken by
	(c) Utilisation of non-edible oilseeds & oils	
1.	Information regarding availability of large quantities of sal seed and utility of its oil in soap. making might be brought to the notice of the solvent extraction factories and soap manufacturing concerns.	Indian Central Oilseeds Committee, and Khadi and Village Industries Commission.
2.	Data regarding the number of solvent extraction plants installed, their capacity, utilised capacity etc. might be collected. In cases where solvent extraction factories evinced some interest, the question of formulating schemes for organising collection of seeds might be considered by the Forest Departments. The required data are being obtained from the Solvent Extraction Factories.	
	(d) Research work on non-edible oilseeds and oils	
1.	A note on 10 or 12 non-edible oilseeds which were available in plenty and on which research work was necessary, indicating the areas where the seeds are available, their quantities and uses, research work so far done, and further work required, may be prepared.	Indian Central Oilseeds Committee, in collaboration with Research Laboratories
	The machinery and processes of de-pulping, drying, decortication, other technical aspects should be standardised and popularized.	Indian Central Oilseeds Committee. in collaboration with Indian Standards Institution.
2.	The resources and technical know-how of the existing laboratories should be pooled in a planned manner so as to entrust them with the responsibility of developing such oils intensively. These are listed below: (*a*) Regional Research Laboratory, Hyderabad; (*b*) Central Food & Technological Research Institute, Mysore; (*c*) Forest Research Laboratory, Bangalore; (*d*) Oil Technological Research Institute, Kanpur; (*e*) Oil Technological Research Institute, Anantapur; (*f*) Department of Chemical Technology, University of Bombay, Bombay. (*g*) National Chemical Laboratory, Poona; (*h*) Harcourt Butler Technological Institute; Kanpur; (*i*) Forest Research Institute, Dehra Dun; (*j*) University Colleges and Technology, Calcutta; and (*k*) Khadi and Village Industries Commission.	Indian Central Oilseeds Committee and Khadi and village Industries Commission.
	(e) Co-ordination of the planned programme among various organizations	
	With a view to make an All-India programme of development of newer fatty oil-bearing plants rerealistic, as pointed above, it will be necessary	Planning Commission.

Sl. No.	Recommendations	Action to be taken by
	to set up an Advisory Expert panel under the Planning Commission, which should review the work of all such centres and make suitable recommendations for their proper organisation and channelization from time to time. This Expert Panel should consist of such members who should not be interested in the actual working of any of these plans in different regions of the country. An active secretariate will be necessary to assist the successful functioning of the Expert Panel to the Planning Commission.	
III.	TOBACCO WASTES AND TOBACCO SEED	
	"Tobacco Waste" is obtained through processing of Bidi, Hookah and Chewing Tobacco or handling of V.F.C. and other aircured tobaccos. This is normally used for agricultural purposes after obtaining permission of the Central Excise Department. Such wastes contain 0·5 to 1·5% nitrogen and 0·5 to 2% nicotine. The possibility of utilising this material economically for the manufacture of nicotine sulphate, nicotinic acid etc. should be investigated, keeping in view that the demand of nicotine sulphate for internal consumption is limited and its export is linked up with the cost of production.	Indian Central Tobacco Committee.
IV	BAGASSE	
1.	Recently some arrangements for supply of alternative fuel to sugar factories in exchange for bagasse have been mutually agreed to between the sugar mills and the promoters of paper projects intending to use bagasse as raw material. Government has come in only by way of encouraging such arrangements and assisting the licencees to implement their projects. Some of these arrangements have been made on no-profit no-loss basis. The paper factories have supplied oil-fired boilers and the necessary fuel to the sugar mills and in turn taken away all the bagasse produced in the sugar mills. Because both the sugar and paper industries are mostly in the private sector, it is felt that this pattern may continue and be actively encouraged by the Government until a substantial portion of bagasse produced in the country is utilised for paper production. A Bagasse-for-Paper Promotion Committee, consisting of the representatives of the Ministry of Food and Agriculture (Directorate of Sugar and Vanaspati), the Department of Technical Development (former Development Wing) of the Ministry of Economic and Defence Coordination and the Planning Commission and the Director, National Sugar Institute, Kanpur, may be constituted which may get in touch with the licencees of bagasse-based paper projects and assist them in bringing their projects into production speedily. If necessary, an expert from the Forest Reserch Institute, Dehra Dun, may be coopted as a member.	Planning Commission.
2.	The National Sugar Institute, Kanpur, has been actively engaged in investigating the causes of	National Sugar Institute, Kanpur.

Sl. No.	Recommendations	Action to be taken by
	excessive fuel and steam consumption in sugar factories and in giving the necessary advice to improve their efficiency. At the instance of the Development Council for Sugar Industry an extension service scheme was started by the Institute in 1957. So far, preliminary survey of 23 factories and final survey of 12 factories have been completed. The extension service facilities provided by the Institute should be augmented so that a larger number of factories can be taken up for survey than at present. There are now about 180 working sugar factories in the country. The target date for the Institute to complete the survey work should not be later than the end of the Third Plan period so that the renovation and modernisation programmes in the sugar factories can be implemented during the Fourth Plan period, preferably the first half of it.	
	As recommended by the Achievement Audit Committee (Thacker Committee) which examined the question of developing the National Sugar Institute to meet the requirements of the industry, the following off-season courses should be started in the Institute for the benefit of the technicians working in the industry :— (*a*) Certificate course in mill and boiler operation and control, (*b*) Certificate course in manufacturing operations and control.	
3.	The Tariff Commission had recommended in their Report (1959) on the cost structure of sugar and fair price payable to the sugar industry that Government should arrange financial assistance to the sugar factories as had been done for cotton and jute textile industries for renovation and modernisation of their plant and equipment. The recommendation is still under consideration of the Government. In order to save bagasse for the paper industry, this recommendation deserves implementation forthwith. Government should also release foreign exchange for importing the plant and equipment which are not yet manufactured in the country or are manufactured in insufficient quantities.	Ministry of Food and Agriculture (Directorate of Sugar and Vanaspati).
V.	ECONOMIC RESOURCES OF MARINE ALGAE	
1.	A survey to assess the quantities of seaweeds available on our coasts and places suitable for "seaweed farms" should be undertaken. Possibilities of of establisihng such "seaweed farms" should be worked out in detail.	Ministry of Food and Agriculture.
2.	At present seaweeds thrown off shore are only collected. Possibilities of collection by mechanised fishing boats, sould be examined.	Do.

Sl. No.	Recommendations	Action to be taken by
3.	Collection of seaweeds should be organised. Centres for drying and marking to the processing centres should be established.	Ministry of Food and Agriculture.
4.	Products of "Seaweed" (e. g. agar, alginic acid, and alginates) should be given due publicity, in order to create a demand for them, Incentives may be offered to the industries like pharmaceutical, cosmetics, textile, paints and varnishes to induce them to utilise these products.	Do.
5.	Economics of a modern processing and utilisation plant located at a central place in the coastal areas should be worked out in detail.	
VI.	BY-PRODUCTS OF FRUIT AND VEGETABLE PROCESSING INDUSTRY.	
1.	As adequate figures are not available regarding the exact quantity of fruit and vegetable wastes from different processing industries, it is necessary that a survey is taken up for this purpose. Such survey should specially cover the waste products of mango, citrus fruits, pineapple, apples and other deciduous fruits, guava, cashewnut, papaya, tomato, potato and pea.	Agricultural Marketing Organisation, Ministry of Food and Agriculture.
2.	Although some investigations have been and are being carried out on the utilisation of fruit and vegetable wastes, especially from mango, banana, papaya, citrus fruits, pineapple, apple, guava, cashewnut, tomato and pea, these researches should be intensified.	Central Food Technological Research Institute, Mysore.
3.	As the quality of the by-products from the processing industry will depend on the quality of the basic materials, i. e. on the varieties of fruits and vegetables and their methods of cultivation, it is necessary to have an intensive collaborative research between the chemists, technologists and horticulturists.	Indian Council of Agricultural Research.
4.	With the information and data available at present, the following steps may be taken for utilisation of wastes: (*i*) Setting up of a mandarin oil and pectin factory in Central India and Coorg. (*ii*) Setting up of a factory at a suitable place for utilisation of wastes from cashewnut particularly cashew apple. (*iii*) Setting up of a small unit at a suitable place for producing vinegar from pineapple waste and Jaman. Preparation of cattle feed from pine-apple may be considered. (*iv*) Setting up of factories for utilisation of seedling mangoes in the mango belts in Punjab, Uttar Pradesh, and Andhra Pradesh. (*v*) A survey should be carried out by the Development Council for Food Processing	Department of Technical Development, Ministry of Economic and Defence Coordination.

Sl. No.	Recommendations	Action to be taken by
	industries regarding the availability of different types of waste from food processing factories.	
VII.	**LAC WASTES**	
1.	Intensive research is necessary for utilisation of the technical dye from stick lac.	Indian Lac Research Institute.
2.	Adequate inducement for the purchase and processing of the crude material collected at the major lac refining centres should be given and ultimately a wax recovery plant should be established at the Indian Lac Research Institute, to handle most of the wax containing waste collected in the region which can also serve as a model for other centres.	Indian Lac Cess Committee.
3.	The lac resin contained in the bye-products, namely seedlac fines, mollama and kiri can be recovered by solvent extraction or by alkali extraction method newly developed at the Indian Lac Research Institute. Proper use should be developed for this bye-products lac (refuse lac).	Do.
VIII.	**WASTES AND BY-PRODUCTS FROM SLAUGHTER HOUSES AND DEAD ANIMALS**	
	A. Slaughter house wastes	
1.	A special survey should be conducted regarding all licensed slaughter houses and detailed information should be collected on the number and present arrangements, if any, for utilising by-products, the proportion of by-products thus utilised, scope offered by individual or group of slaughter houses for economic utilisation of by-products.	Indian Council of Agricultural Research and State Govts.
2.	Bleeding rails should be provided in the slaughter houses. A blood gutter may be provided with two outlets, one leading to the blood tank situated in the by-products building, and the other leading to a sewer. The blood gutter must have a good slope as blood clots rapidly and its entrance should be covered with l.w perforated steel plates to prevent contamination.	Do.
3.	The inclusion of a rendering plant in slaughter houses located in large cities is highly desirable in order to ensure collection and rendering of raw fat daily.	Do.
4.	Adequate accommodation in slaughter houses for the hygienic processing and storage casings, provision of simple type of machinery for gut cleaning, etc, and ample supply of fresh water would be necessary to facilitate manufacture of good quality casings.	Do.
5.	Provision of special containers, freezing units, refrigeration facilities for the collection and storage of various glands would be required to minimise the wastage occurring at present, particularly of the pituitary, thyriod, partthroid glands, etc.	Do.

Sl. No.	Recommendations	Action to be taken by
6.	Provision of rendering plants for the conversion of condemned meat into meat-meal is highly desirable to ensure large returns from the slaughter houses.	Indian Council of Agricultural Research and State Govts.
7.	It is necessary to train personnel engaged in the slaughter houses to ensure the hygienic production of meat and the proper utilisation of by-products.	Do.
8.	Immediate action to be taken for setting up two modern slaughter houses at Bombay and Calcutta.	Do.
9.	The scheme for modernising slaughter houses already included in the third plan should be implemented early	Do.
10.	The economics for the setting up of a glandular products project for which applications have been received, should be examined.	Do.
11.	The Working group for the Fourth plan should give due consideration to the need of modernising slaughter houses in the country and for the use of waste from dead animals.	Planning Commission
	B. *Wastes from dead animals*	
	I. *For immediate adoption for increased production :*	
1.	Collection of bones of the dead animals requires to be organised on intensive scale. Community Development Organisation in collaboration with Khadi and Village Industries Commission can work out a scheme of organising the bone collection.	Ministry of Community Development and Khadi and Village Industries Commission.
2.	Use of bone digesters for preparation of meat meal, bone meal and extraction of fats should be popularised.	Ministry of Food and Agriculture, Khadi and Village Industries Commission and Planning Commission.
3.	Suitable facilities for training and other technical guidance for the utilisation of wastes from dead animals should be provided on State or regional basis.	Khadi and Village Industries Commission.
4.	Centres for the utilisation of bones should be organised on scientific lines.	Ministry of Community Development and Khadi and Village Industries Commission.
	II. *For future investigations :*	
5.	Investigations should be carried out to improve the flaying techniques including improvement of implements for flaying.	Central Leather Research Institute and Khadi and Village Industries Commission.
6.	Indigenous techniques adopted by Village "Chamars" in the utilisation of carcass need to be improved and it is desirable that scientific investigation in this direction should be intensified.	Ministry of Food and Agriculture, Central Leather Research Institute and Khadi and Village Industries Commission.

Sl. No.	Recommendations	Agency to take action
	III. *Future Survey necessary :*	
7.	Survey should be carried to find out the availability of bones from various accessible and inaccessible parts of the country in order to meet the requirements of indigenous industry for the manufacture of ossein and special gelatine for internal use and also export enough bone ghrist for foreign exchange.	Khadi and Village Industries Commission.
IX.	FISHERY WASTES	
1.	The main sources of raw material for the production of fish meal in India are : (*i*) residues left after extraction of oil from oil sardines; (*ii*) trimmings and other wastes from fish curing yard; (*iii*) trash fish landed along with quality fish and (*iv*) fish that remain in excess of market requirements or of processing facilities during seasons of glut. It has been estimated that if the fish-meal industry is organised on proper lines, an average of 30—40 thousand metric tons of meal could be manufactured from oil sardines alone annually. The present production falls far short of this estimated quantity. One positive step for full exploitation of the wastes mentioned above would be to organise the fish-meal industry on small scale or cottage industry basis, through the State Fisheries Departments. To start with, small production units may be established near important fish which will provide sufficient raw material in the form of wastes and trimmings for the units. Such units may also be located near fishing harbours to handle trash fish which is estimated to constitute, nearly 10% of the landed fish.	State Governments of Kerala, Madras and Bombay.
2.	The small scale fish meal drying unit developed at the Central Institute of Fisheries Technology may be recommended to interested parties by the Fisheries Departments. The product at present prepared from sardines and marketed under the name 'sardine guano' is a very wasteful use of protein material. It still contains enough oil to reduce its value as fish meal. If a series of small drying units mentioned above is installed in the sardine fishing areas, the excess quantities available during the glut season, could be converted into good quality fish meal.	State Government concerned.
3.	There is increasing demand for fish meal within the country for poultry or cattle feed. The products produced in different centres may be collected in central places for preparation of mixed feeds and disposal.	State Governments concerned.

Sl. No.	Recommendations	Agency to take action
4.	The most important source of fish oil in India is oil sardines, which contain about 16% of its weight of oil. Assuming the yield of oil at 10% of the weight of the fish, it will be possible to get about 19,000 metric tons of sardine oil. However, the amount of sardine oil produced in India in recent years is about 4 to 5 thousand tons per year. Thus, it will be observed that there is scope for development of this industry. The larger production of sardine oil, however, would be limited by its demand. At present, sardine oil is used mainly for coating the local fishing boats. Due to its poor quality, it does not find a market in other industries like cosmetics, soap, hydrogenated fat, leather, tile, etc. which could use a good amount of this oil. Good sardine oil can also be used in the canning of fish. At the Central Institute of Fisheries Technology, an improved method or processing and extraction has been developed and if this simple modified method is widely used, it will result in a production of much better quality of oil. The States of Kerala, Mysore and Maharashtra may be requested to introduce small scale extraction of good quality oil with immediate effect. Demonstration units may have to be operated at centres like Calicut and Mangalore.	State Governments concerned.
5.	Liver oil industry should be expanded. At least one small plant should be set up in each of the maritime states to process and refine oil produced in the different centres of the States.	Do.
6.	The possibility of manufacturing fermented fish products like fish sauce from certain species of fish like leiognathusk, gazza and species of clupeids has been well established by the Central Institute of Fisheries Technology. These types of fish are landed in large quantities along the East Coast and the total catch is estimated to be around 35·70 thousand metric tons. Pilot units may be started at selected centres along the East Coast under the auspices of the State Governments for producing fish sauce from the species mentioned above.	Do.
7.	Over 4,500 tons of skates and rays are caught annually in India. The livers from these varieties of fish are not being utilised commercially at present. Although the oils may not be rich in Vitamin A, as indicated by preliminary studies carried out at Central Institute of Fisheries Technology, there is scope for further investigations on their composition and possible uses. A detailed study of the composition of these oils has to be carried out with a view to find out if they contain any commercially important compounds. As the fishery is dispersed all along the coast, extraction of oil has to be carried out on small scale in selected centres and the product collected at a central laboratory for refining and further study.	Central Institute of Fisheries Technology and Central Food Technological Research Institute.

Sl. No.	Recommendations	Agency to take action
8.	In the prawn freezing and canning industry, shells and heads form an important waste product which contains roughly 30-40% of protein on dry basis. On the basis of present production nearly 120 tons of dried product may be available annually for conversion into useful product. Most of this is thrown away as waste at present. Except for attempts at dry prawn production centres to powder the shell waste, no organised attempt has yet been made to fully utilise this important product. Investigations have, therefore, to be taken up to study the best methods of utilisation of such wastes. One possible form of utilisation is to mix the shell powder with ordinary fish meal in definite proportions to produce mixed feed, for poultry. Such a product will find a ready market within the country. The programme of work should include efficient drying and powdering of the shell materials at the source, and transportation to selected central places where mixing has to be carried out. Experimental work has also to be carried out to determine the optimum level of mixing and the feed value of different mixtures.	Central Institute of Fisheries Technology and Central Food Technological Research Institute.
9.	Certain preliminary studies have been carried out at the Central Institute of Fisheries Technology, Ernakulam and Central Food Technological Research, Mysore on production of edible fish flour for human consumption from surplus fish and fish wastes. This work has to be further extended. The future programme of work shall include (*a*) evolving cheap and efficient methods for conversion of fish into fish flour, (*b*) Controlled hydrolyses of fish waste to produce egg white substitute, (*c*) acceptability trials along with trials to incorporate the products in common food materials, (*d*) utilisation of fish flour in the products in common food materials.	Do.
10.	The possibilities of preparing *Smoked bones flakes* from sardines have to be taken up for detailed investigations. Experimental work will have to be carried out on the optimum conditions of production. If successful, this may open up a new avenue for utilisation of excess sardines during the glut seasons. Similar products from herrings are considered as a delicacy in foreign markets.	Do.
11.	Extensive study will have to be carried out on the possibility of manufacturing Pearl Essence from ribbon fish. The percentage availability of raw material and other aspects need careful consideration. The possibility of using the skin and scales of other types of fish also will have to be examined.	Central Institute of Fisheries Technology.
12.	At present there is no fish glue industry in India. This can be taken up only as an adjunct to large scale processing industries when skins and head form as waste. Preliminary experiments conducted at the Technological laboratory at Bombay showed that good grade glue and gelatin could be prepared from fish skins. This problem, therefore, required further survey and study.	Do.

Sl. No.	Recommendations	Agency to take action
X.	BLAST FURNACC SLAG	
1.	It would appear that the schemes licensed for the manufacture of slag cement have not progressed satisfactorily. In view of the acute shortage of cement in the country, immediate steps should be taken for the manufacture of slag cement on a fairly large scale, Towards this end, the installation of a granulation plant at Durgapur should be expedited.	Ministry of Steel and Heavy Industries and Department of Technical Development, Ministry of Economic and Defence Coordination.
2.	It appears that the use of blast furnace slag as a raw material for glass-making and as a soil additive has not been investigated in India so far. It is recommended that the Central Glass and Ceramic Research Institute, Calcutta and the Indian Agricultural Research Institute, New Delhi should take up investigations on these aspects of slag utilisation.	Central Glass and Ceramic Research Institute, Calcutta and Indian Agricultural Research Institute, New Delhi.
3.	It is felt that blast furnace slag should be used for stowing purposes, wherever feasible. It has been used for this purpose in some mines in European countries. The Central Mining Research Station, Dhanbad should investigate the feasibility of using blast furnace slag for stowing purposes as there is a shortage of stowing material in a number of places in the country.	Central Mining Research Station, Dhanbad.
XI.	BASIC SLOG	
1.	The possibility of using basic slag for conditioning acid soils of India and of supplying phosphate to such soils in conjunction with organic matter should be examined.	Ministry of Food and Agriculture.
2.	The question of making basic slag available, in desired finely ground form, to the actual users at economic rates should be studied by the Ministry of Food and Agriculture and the Ministry of Steel and Heavy Industries (Department of Iron and Steel) so that it may be utilised for increasing agricultural production particularly in the acidic soil areas in the States of West Bengal, Orissa, Bihar and Madhya Pradesh, where steel mills are located. In case basic slag is made available to the farmers at a cheap rate with adequate concessions in railway transport charges, the demand for this material is likely to go up and the chances of conditioning large areas of acidic soils become brighter.	Ministry of Food and Agriculture and Ministry of Steel and Heavy Industries (Department of Iron and Steel).
3.	The possibility of enriching basic slag in its content of P_2O_5 by mixing the molten material with indigenous rock phosphate may be explored.	Do.
XII.	UTILISATION OF BY-PRODUCTS OF COAL CARBONISATION	
1.	The requirement of toluene is gradually increasing and immediate efforts should be made for the maximum recovery of crude benzol and preparation of the products, benzene and particularly toluene. While efforts should be made to recover maximum amount of benzol from the existing	Ministry of Steel and Heavy Industries, Ministry of Mines and Fuel and Industry and Minerals Division of the Planning Commission.

Sl. No.	Recommendations	Agency to take action
	steel works, consideration should be given to the setting up of a plant in the aromatics unit at the Gujarat oil refinery to produce annually 15,000 tons of toluene which will meet our toluene requirements and also for producing benzene through aromatic units attached to petroleum refineries.	
2.	The steel companies may expand their coke ovens so as to obtain additional quantities of coke and gas and thereby reduce to a minimum the amount of crude tar burnt as fuel in the steel melting shops. Whatever crude tar is saved by this means should be distilled to recover naphthalene.	Ministry of Steel and Heavy Industries.
3.	None of the coke oven plants in the country has made any provision for the recovery of tar bases such as picolines, pyridines and quinoline. It is necessary and desirable that all the coke oven plants recover crude tar bases and these be collected at one central place for further separation and purification.	Do.
4.	Recovery and rectification units in Tata Iron and Steel Works have not been working efficiently resulting in loss of crude benzol and necessary action should be taken by them to put these units in working order.	Ministry of Steel and Heavy Industries, and Industry and Minerals Division of the Planning Commission.
XIII.	By-Products of Salt Bitterns	
	The salt bitterns now available as waste are concentrated in the coastal regions of Gujarat and South-Eastern Madras having a large number of salt factories. There are, however, only a few salt producers who can mobilise substantial quantities of salt bitterns for commercial exploitation. It would, therefore, be necessary to set up an industry for recovery of chemicals, with particular reference to potassium chloride and bromine, with the cooperation of salt producers in the region so that a unit of economic size for the recovery of marine chemicals available as by-products is established. It is also considered necessary to undertake a survey of the total quantity of bitterns available in different regions with a view to deciding on the location of such a project. Kandla, Jamnagar, Bhavnagar, Tuticorin are some of the places which can be considered for this purpose.	Department of Technical Development, Ministry of Economic and Defence Coordination and Council of Scientific and Industrial Research.
XIV.	Coal Ash	
1.	The Digvijay Cement Factory should examine the feasibility of using fly ash from Trombay for manufacturing pozzolanic cement at their Bombay unit where capacity for mixing, grinding and packing is available. Pozzolan cement could then be supplied to consumers in Bombay from this source.	Department of Technical Development, Ministry of Economic and Defence Coordination.
2.	Fly ash from the Delhi Power House might be used by the Associated Cement Companies Ltd. for manufacturing pozzolan cement at Okhla where they have installation for bulk handling of cement.	Do.

Sl. No.	Recommendations	Agency to take action
3.	The Churk factory should examine the feasibility of either transporting fly ash from Kanpur Power House to Churk or of bringing clinker from Churk to Kanpur for intergrinding with fly ash at Kanpur.	Department of Technical Development, Ministry of Economic and Defence Coordination.
4.	Slimes available at Kolar Gold Fields should also be utilised for manufacturing pozzolan cement and Mysore Cements should be asked to make out a scheme.	Do.
5.	A cement-fly ash intermixing unit might be set up at a suitable place in the D.V.C. area for taking care of the demand for cement in that area. Also, a party might be licensed to set up a factory for manufacturing pozzolan cement at Calcutta based on either transporting clinker from cement factories in Bihar and intergrinding it with fly-ash or mixing fly ash with portland cement.	Do.
6.	A pozzolan cement unit may be considered for Bokaro based on fly ash from Chandrapura, about 5—6 miles away.	Do.
7.	20 per cent of fly ash may be mixed with cement without deterioration in quality. The possibility of this use of coal ash will depend upon the extent to which the cement can be used locally. Fly ash may also be used for making building blocks. This concerns three Ministries, *viz.*, Works, Housing and Rehabilitation; Steel and Heavy Industries and Irrigation and Power, who should be addressed on the subject and the matter should be followed up.	Industry and Minerals Division, Planning Commission.
XV.	MICA WASTE	
1.	The Department of Technical Development, Ministry of Economic and Defence Coordination and the National Research Development Corporation should continue their efforts to interest enterpreneurs to set up a factory in India for the manufacture of wet ground mica using the process developed by the Central Glass and Ceramic Research Institute. If no enterpreneur comes forward within a reasonable time, due to shyness to try a new method, the National Research Development Corporation should arrange to try the process on a semi-commercial scale with a view to verify that it produces a material which is acceptable in foreign markets at an economical price.	Department of Technical Development, Ministry of Economic and Defence Coordination and the National Research Development Corporation; also Industry and Minerals Division, Planning Commission.
2.	The Central Glass and Ceramic Research Institute should continue research in finding new uses f. ground mica or mica waste directly and the National Research Development Corporation should give due publicity to results of the research with a view to their adoption in the industries concerned.	Central Glass and Ceramic Research Institute and the National Research Development Corporation; also Industry and Minerals Division, Planning Commission.

CONVERSION TABLE

One lb.	0.4536 Kg.
One maund	37·324 Kg.
One ton	1.016 metric ton (tonne)
One yard	0·9144 metre
One acre	0·4047 hectare

For conversion of temperature in Fahrenheit °F to Centigrade °C the relation is **C=5/9 (F—32)**

L9PC/63—2,000—1-2-64—GIPF.