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Expert group meeting on pre-investment considerations and technical and economic production criteria in the oilseed processing industry.
Vienna, Austria 16 - 20 October 1972

RICE BRAN PROCESSING FOR THE PRODUCTION OF RICE-BRAN OIL AND RICE-BRAN PROTEIN MEAL [1]

by

Kenzo Yokochi
Director and Chief Engineer
Rice-Bran Oil Technical Research Institute
Tokyo, Japan

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SUMMARY 1/

RICE BRAN PROCESSING FOR THE PRODUCTION OF RICE-BRAN OIL AND RICE-BRAN PROTEIN MEAL

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The paper draws attention to the failure in many countries to use rice-bran as a source of oil. Not only does rice-bran oil contribute to health improvement, but de-oiled rice bran can also be used as a basic material for animal feed.

Despite the fact that raw bran has a disadvantage in common with other vegetable oil raw materials, i.e. the oil-content rapidly changes into free fatty acids following lipo-oxydation, hence increasing the acid values, it is not only easy to refine, but the fact that glycerine is a by-product makes it highly suitable for the manufacture of fatty acids and/or soaps. Following esterification, it can be used in the manufacture of cutting oils and vinylchloride for example.

The important factors in the production of oil are: the quality of the raw bran, the extracting equipment used and the technical standards applied. The paper offers an analysis of various brans and tabulates the increase in acid value in summer and winter.

The author advocates more stringent control of the rice milling processes to avoid contamination and suggests incorporating rice-bran oil extraction plants and milling plants to ensure a supply of fresh material, prevent loss in weight, reduce transportation costs, stabilize operational expenses and reduce capital requirements. Flow-charts and tables are presented referring to the composition of rice-bran, de-oiled bran, and bran-oil, their uses and special characteristics.

The paper also describes stabilizing procedures to permit the storage of bran for periods of up to three months. Data are quoted from experiments carried out by the Japanese Food Research Institute to indicate the relationship between the storage of rice bran and the increase in the fatty acid content.

The paper also describes the solvent extraction process as opposed to the mechanical method of oil extraction. Details are given of batch-type solvent extraction processes and continuous extraction methods. Flow sheets are shown and the salient features of both processes are described together with drawing and plant lay-out diagrams. Material requirements for both batch-type and continuous processes are quoted; figures relating to fuel consumption and electrical power requirements are given together with a brief cost/benefit analysis.

A close analysis of the advantages and disadvantages of both extraction processes is schematically presented, the conclusion being that batch systems are to be recommended where capital investment is limited, a skilled engineer and adequate labour force are available and no repair shop is on hand. A continuous system is to be preferred where a variety of raw materials is to be processed and there is no shortage of starting capital; continuous extraction processes are also of advantage when labour costs are high, but they demand a highly developed attitude towards work.

The paper also describes the exact composition of rice-bran oil and shows how crude, semi-refined and refined oils can be put to best advantage. The author describes various refining processes: the alkali deacidification refining method which is considered safest, the distillatory deacidification method and bleached clay de-colourization systems.

The paper describes the manufacture of salad oil, frying oil and cooking oil and flow charts are shown for the caustic-solution (alkali) process and distillatory deacidification process. Costs of the two processes are compared with plant lay-outs presented.

The author also presents details of soap manufacture from rice-bran oil which can be twice as cheap as other soap materials such as coconut and other vegetable oils. In view of the ban on the sale of detergents in certain areas, pure vegetable soap will become increasingly popular. The production of soap helps to make small plants profitable as well as to improve local sanitary conditions.

The paper also shows the effective utilization of de-oiled rice bran as opposed to raw bran in cattle feed, as a fertilizer, in seed beds, for medical purposes as well as a human food. Further details are given on the possibilities of using rice germ meal for human consumption, more precisely the culture of aspergillus orzae, eremothecium ashbyii and active lactobacillus moulds on rice germs and dry yeast, all of which are combined in wakamoto tablets.

The paper closes with an analysis in tabular form of the protein content, essential amino-acid content, moisture content, oil extraction rate, etc., in rice bran.

INTRODUCTION

Rice bran is a by-product of the rice-processing industry. Although it is produced in large quantities and is a valuable source material, it is still left unutilized in the rice producing countries of South-East Asia and other areas.

Rice bran, however, should be used as much as possible to produce oil. In some countries, interest in the production of rice bran oil has indeed been noted, and the production of rice-bran oil has developed since World War II in such countries as Burma, the Republic of China, India and Thailand. Nevertheless, in most rice producing countries, rice bran is still not utilized. *

An increased supply of oil resulting from the processing of rice bran would contribute to the improvement of the people's health and welfare in these countries, and de-oiled rice bran might serve to increase the supply of animal feed.

In the paper, the author will discuss rice-bran oil production techniques with particular reference to his experience in this field and the problems he has encountered in the development of the rice bran oil industry in many countries.

As the author once surveyed the rice-bran oil industry's development in Burma, India, Nepal and Thailand as well as Mexico, he will refer mainly to these countries when discussing the development of the industry.

CHAPTER I. RICE BRAN, A SOURCE MATERIAL FOR EDIBLE OIL AND RICE PROTEIN

Rice Bran Industry

Raw bran once removed from brown rice through the whitening process, is prone to enzymal fermentation even at normal temperatures which inevitably leads to deterioration of the oil content. Lipolytic enzymes cause hydrolisis of the oil as seen by the free fatty acid increase which renders much of the oil unsuitable for human consumption. It also causes indigestion and/or diarrhoea if fed to cattle or poultry.

Despite such shortcomings, raw bran is still widely used in Japan as feed for dairy cattle or as a fertilizer since it is easily obtained by the farmers who have their own rice milling facilities. On the other hand, raw bran is sometimes difficult to obtain as oil extraction plants are usually located in urban areas and supply neighbouring meal plants direct.

However, it should become much more easily obtainable in the near future, even for farmers, when large-scale rice mills and oil extraction plants are built in rural areas to increase rice bran output in accordance with the authorities' centralization/rationalization programmes. At the moment, the government is planning modern mills to promote an ideal direct contact process combining conventional rice milling and oil extraction processes. Should the plan materialize, previous procurement and transportation costs will be extensively reduced and, even better, fresh bran can be utilized immediately to produce a quality crude oil with lower acid values.

This oil is not only easier to refine, but it lends itself to the production of superior cooking oil. On top of that, it is remarkable for the fact that the glycerine by-product can be used in the manufacture of fatty acids and soaps.

Furthermore, high-acid rice-bran oil is regarded as an important raw material source for producing superior soaps, the solubility of which is excellent even in cold water. After the oil has been esterified, it can be used to manufacture improved cutting oils and vinylchloride. Hence, it can contribute effectively to the development of national industries.

As seen from the above, it is not an exaggeration to say that the utilization of rice-milling by-products throws fresh light on the nation's future in terms of industrial materials as well as offering a partial solution to food problems.

Different Rice Bran Qualities

The all-important factors in rice-bran oil industry are, the quality of the raw bran, the oil extraction machinery and the technical standards applied. The 'goodness' or 'badness' of the brown rice itself definitely affects rice bran qualities. The oil content and other ingredient ratios range from 17% to 22% (on an average 20%) subject to the strain and quality of rice.

The major disadvantage of rice-bran is that unlike other common vegetable-oil material it rapidly changes into free fatty acids due to 'lipolysis'. For example, the acid values in rice bran sometimes increase at the rate of more than 5% FFA per day even at a temperature of 23-24°C. Consequently, great care should be taken to select best quality fresh material.

Table 1. Analysis: brown rice, white rice, rice bran

	Brown Rice	White Rice	Rice Bran (1)	Rice Bran (2)	Rice Bran (3)
Water	13.30	13.91	11.46	13.5	11.6
Crude protein	8.80	7.72	15.08	14.8	12.5
Crude fat	2.20	0.77	20.00	18.2	20.3
N-Free extract	73.40	76.79	37.64	35.1	35.0
Crude fibre	1.00	0.25	7.32	9.0	12.2
Crude ash	1.30	0.57	8.43	9.4	10.5

Table 2. Rice bran analysis and physical structure of Nepalese and Japanese bran

		Nepalese Rice Bran	Mexican Rice Bran	Japanese Rice Bran
Bran Analysis	Water	9.0%	9.1%	12.7%
	Crude protein	13.0	11.9	15.1
	Crude fat	15.0	15.2	20.0
	N-Free extract	30.5	48.6	34.6
	Crude fibre	18.5	6.5	9.3
	Crude ash	14.0	8.7	8.3
Physical structure of bran	10 mesh	4.0%		0.2- 2.0
	20 mesh	2.0		4.2-14.0
	30 mesh	5.2		12.0-28.0
	50 mesh	72.4		42.0-62.0
	80 mesh	10.4		2.0-16.0
	100 mesh	4.0		0.5- 2.0
	150 mesh	2.0		-

Table 3. Analysis: Nepalese rice bran from huller and cone-type mills

Rice Mills (Region)	Water %	Crude Fat %	Acid Value	Remarks
Nepal Terai BHADRAPUR	9.8	4.5	48.0	Parboiled rice bran Huller type mill
BIRATNAGAR	11.0	9.0	52.0	" " "
BIRGANJ	12.5	6.0	40.2	" " "
POKHARA	10.8	7.6	66.0	" " "
BIRATNAGAR	12.0	16.0	62.0	Parboiled rice bran Cone-type mill

Influence of rice milling on rice-bran quality

• The most important fact is that huller-type rice milling machines, such as those used in India, Indonesia, Malaysia, Nepal, Pakistan and the Philippines, produce a complete mixture of fine husk and bran particles. The oil content is consequently low 4% - 8% and the bran is unsuitable for extracting oil. It is necessary that rice mills be designed to separate pure rice bran from husk, i.e. all Japanese type mills or cone-type mills (British, German, and Italian models).

Constant FFA content increase during storage

Table 4.

Test (1)

Acid Value Increase (Summer)

Test No.	Date	Weather	Room Temperature °C	Room Humidity %	Raw Rice Bran Temperature °C	Raw Rice Bran Water Content %	Raw Rice Bran Acid Value	FFA Content %	Colour of oil
1.	8.24	Fine	28.5	77.0	29.5	11.39	17.88	9.00	yellow-green
2.	25	"	30.5	75.0	29.5	-	23.86	12.00	"
3.	26	"	29.3	79.0	30.0	-	24.62	12.39	"
4.	27	Rain	29.5	82.0	31.0	-	25.05	12.60	"
5.	28	Fine	30.0	80.0	32.0	-	37.13	18.68	yellow
6.	29	"	30.5	76.5	30.0	-	57.33	28.84	"
7.	30	"	31.0	77.5	30.5	11.73	74.55	37.51	"

Table 5.

Test (II)

Test No.	Date	Weather	Room Temperature °C	Room Moisture %	Raw Rice Bran Temperature °C	Raw Rice Bran Water Content %	Raw Rice Bran Acid Value	FFA Content %	Colour of Oil
1.	6.26	fine	33.0	67	30.4	11.86	24.25	12.30	yellow-green
2.	7. 3	cloudy	22.5	80	28.0	9.62	55.78	26.06	yellow
3.	10	fine & rain	28.0	78	33.4	10.36	95.68	48.14	"
4.	17	fine	32.0	70	34.3	10.32	114.87	57.79	yellow-red
5.	24	"	30.0	87	32.9	9.27	115.11	57.91	"
6.	31	"	31.0	67	35.3	9.54	134.16	67.08	yellow-green
7.	8. 7	"	32.0	72	34.5	9.23	137.22	69.04	"
8.	14	"	34.0	62	33.5	9.45	123.86	62.31	"
9.	21	"	32.0	55	29.0	11.43	128.32	64.56	"
10.	28	"	31.0	64	30.0	9.16	158.48	70.73	"

Table 6.

Test (III)

Acid Value Increase (Winter)

Test No.	Date	Raw Rice Bran Temperature °C	Raw Rice Bran Moisture Content %	Raw Rice Bran Acid Value	FFA Content %	I. V.	S. V.	Colour of Oil
1.	1.21	1.2	13.2	19.59	9.79	108.9	188.7	green yellow
2.	22	9.2	12.7	22.02	11.01			"
3.	23	9.1	13.0	22.15	11.07			"
4.	25	6.6	13.4	23.42	11.71			"
5.	26	6.1	13.2	23.82	11.91			"
6.	27	5.8	13.2	25.40	12.70			"
7.	28	5.8	12.3	25.91	12.95	107.9	189.4	"
8.	29	5.4	12.8	26.25	13.12			"
9.	30	5.1	12.5	26.71	13.35			"
10.	2. 1	4.9	13.0	27.41	13.70			"
11.	2	4.5	12.6	30.49	15.24			"
12.	3	4.6	12.2	29.86	14.93			"
13.	4	4.9	12.7	31.00	15.50	108.7	189.7	"
14.	5	5.1	12.8	30.04	15.02			"
15.	6	5.4	12.2	29.01	14.50			yellow
16.	8	5.5	12.2	32.22	16.11			"
17.	9	5.5	12.0	32.30	16.15			"
18.	10	5.4	12.0	33.14	16.57			"
19.	12	5.5	12.6	37.08	18.54	108.9	190.1	"
20.	13	5.4	12.4	36.02	18.01			"
21.	15	6.3	12.2	38.12	19.06			"
22.	16	6.3	12.0	40.92	20.46			"
23.	17	6.6	12.0	41.16	20.58			"
24.	18	6.0	11.2	40.45	20.22			"
25.	19	5.8	11.6	39.13	19.56	108.6	190.7	"
26.	20	6.0	11.6	38.27	19.13			"

Rice-bran storage and oil extraction rate versus acid-value increase

After processing, rice bran undergoes a change and tends to deteriorate during storage. This change is caused by the interaction of moisture content, temperature, humidity and enzymes.

The lipases or lipolytic enzymes which constitute the greater part of lipase, an enzyme, all the enzymes present attack the fat and liberate the free fatty acids. Therefore, the oil should be extracted from the bran before lipase activity sets in to prevent free fatty acid increase.

The data below were obtained in tests conducted by the Food Research Institute (Ministry of Agriculture and Forestry) to establish the relationship between the period of storage and the free fatty acid increase.

1. **Objective:** To compare the oil extraction rate and the free fatty acid increase using rice bran stored during the warm season.

2. **Test Procedure:** 70 bags of rice bran (33.75 Kg each) were put into storage. Each week, seven bags were withdrawn, the temperature was measured and the oil extracted, the oil-extraction rate and colour of the oil were noted.

3. **Test site:** Nakagawa Rice Processing Plant, Ministry of Agriculture and Forestry, and Oil-Extraction Plant, Food Research Institute, Ministry of Agriculture and Forestry.

4. **Samples:** Niigata Grade 4, Akita Grade 5, Motoishi Grade 5, and Furiki Grade 5.

5. **Test Period:** 65 days, 25 June - 28 August.

Table 7.

Recovery	Date	Weather	Temperature Inside storage area °C	Temperature Outside the storage area °C	Humidity Inside the storage area %	Humidity Outside the storage area %	Mean temperature Inside °C	Mean temperature Outside °C	Moisture content %
1st	June 26.	Fine	28.8	33.0	74	67	28.7	30.4	11.86
2nd	July 3.	Cloudy	23.0	22.5	85	80	28.2	28.0	9.62
3rd	10.	Fine later rain	24.0	28.0	81	78	38.0	33.4	10.36
4th	17	Fine	30.5	32.0	63	70	35.3	34.3	10.32
5th	24.	"	33.5	30.0	56	87	35.8	32.9	9.27
6th	31.	"	26.5	31.0	78	67	34.2	35.3	9.54
7th	Aug. 7.	"	33.5	32.0	63	72	36.3	34.5	9.23
8th	14.	"	17.4	34.0	89	62	33.5	33.5	9.45
9th	21.	"	23.0	32.0	83	55	29.0	29.0	11.43
10th	28.	"	31.0	31.0	77	64	30.0	2[illegible].0	9.16

Note:

The colour was observed with the naked eye, the sample being placed in a glass tube (Ø 95 cm, h 90 cm)

Temperature and humidity were measured at 11:00 hrs.

t	Kettle	Oil extraction period Low pressure 1,000 lbs/m^2	High pressure 3,800 lbs/m^2	Amount of oil extracted kg	Amount of meal kg	Oil extraction rate %	Acid value	Oleic acid FFA %	Colour
	105	15 min.	5 min	24.4	182.6	11.43	24.24	12.20	Yellow
	106	15	5	20.4	172.0	10.40	55.78	28.06	"
	105	15	5	17.5	165.0	9.33	95.68	48.1	"
	106	15	5	20.0	186.8	9.63	114.87	57.79	Dark yellow
	105	15	5	14.2	154.0	8.19	115.11	57.91	" "
	105	15	5	16.0	173.0	8.25	84.16	42.34	" "
	105	15	5	17.4	170.8	8.97	137.22	69.09	" "
	105	15	5	18.5	161.2	9.99	123.86	62.31	" "
	105	15	5	17.6	170.0	8.91	128.32	69.56	" "
	105	15	5	18.5	177.4	9.61	158.78	74.73	" "

Table 8. Chemical composition of oil: protein, fibres and moisture

Analysis: Rice Bran & De-oiled Bran

Analysis No. 1

by: Prof. Saito, Akita University
at: Hatano Lab., Tohoku University
on: March 1956

Compounds	Raw Bran %	De-oiled Bran (pressed) %	De-oiled Bran (extracted) %
Water	12.59	9.39	12.28
Crude protein	13.31	16.07	17.31
Crude fat	21.21	11.21	1.32
N-free extract	34.44	41.13	45.49
Crude fibre	9.05	10.79	11.59
Crude ash	9.40	11.41	12.01

Bran as an important source of oil and meal

Today, it is widely know that rice-bran oil can be refined to salad oil, where holding a special place as a useful edible or industrial oil. Thus, particular consideration must be devoted to the extraction of oil from rice bran. To do this, the bran must be pure, and free of such impurities as husk or broken rice.

However, the present situation in INDIA, INDONESIA, MALAYSIA, NEPAL, PAKISTAN, the PHILIPPINES and other Asian countries is such that the existing facilities permit husk and bran contamination during the milling process, making post-milling separation very difficult. It would thus, be easier and more economical to rationalize existing rice milling processes, rather than to consider separating husk and bran.

Development of new rice mills with ancillary bran-oil plants

It is necessary that rice-bran oil-extraction plants be built in the rice-mill compound and be closely linked with the mill. In Japan and certain other countries, it has been customary to erect oil-extraction plants independently of the rice mills, thereby incurring a heavy economical burden through the collection of the bran. On the other hand, in a country like Nepal where many milling plants are concentrated in a relatively small area, it would be advisable to rationalize new milling plants, and to plan the construction of more plants to extract rice-bran oil from the bran produced by the rice mills.

Profitable merger of rice-bran oil-extraction plants and rice mills

Rice-bran oil-extraction plants which are linked with rice mills have an enormous advantage over others for various significant reasons which are listed below.

Fresh material supply

As already emphasized above, the degree of freshness in the rice bran is one of the most important factors of oil extraction. Hence, linking a rice mill and a rice-oil extraction plant is ideal as it ensures a constant supply of unoxidated fresh bran and consequently a high yield of a quality crude oil with a low free fatty acid content. This is underlined by the fact that low-acid bran, i.e. not exceeding 10 AV offers a high yield of crude oil (18.5 - 9.0 per cent), approximately eighty per cent of which may be turned into edible oil.

Prevention of weight loss

At the moment, it is widely recognized that raw rice-bran undergoes an over-all weight loss of about 5 per cent before it arrives at the oil-extraction plant. However, delivery periods, however short, disappear completely when the direct link system, described above, is employed.

On the assumption that 5 per cent loss in weight of the raw rice bran is thus prevented, the return in raw material costs per bag is 5 per cent of ¥600, i.e. ¥30 (US $8). Furthermore, a high yield of quality de-oiled bran with high nutritive value can be expected.

Curtailed collection/transportation charges

Transportation facilities such as screw-conveyers or pneumatic transporters carry the raw rice bran produced in the rice mill direct to the rice oil extraction plant, hence lowering collection/transportation charges, which hitherto cost up to ¥30-50 per bag.

Upgraded material returns

The "direct link system" ensures a supply of the raw rice-bran, the acid value of which is lower than the presently supplied material by some 10 - 15 AV. It is calculated that an extra ¥30-45 be added profitwise as the lowering of acid value is believed to offer a return of ¥3 (approximately US ¢1) per 1 A.V.

Stabilisation of operational expenses

One of the advantages of the direct link system is that the previous fluctuations in the purchasing price of the raw material and in the selling price of the by-product can be avoided by concluding agreements with the rice millers and the purchases of de-oiled bran, such as agricultural or dairy co-operatives, thereby fixing the cost and/or price. For instance, raw bran could be purchased at ¥660 (about US $1.67) per 30 Kg. bag and the de-oiled bran sold at ¥550 (approximately US $1.53) per 25 Kg. bag.

Potential reduction of working capital

The sum paid by the purchasers of de-oiled bran may be used to settle a great amount of the payments to the rice millers, thereby alleviating the need for working capital.

Fig.

PADDY DRYING PLANT —— flow chart

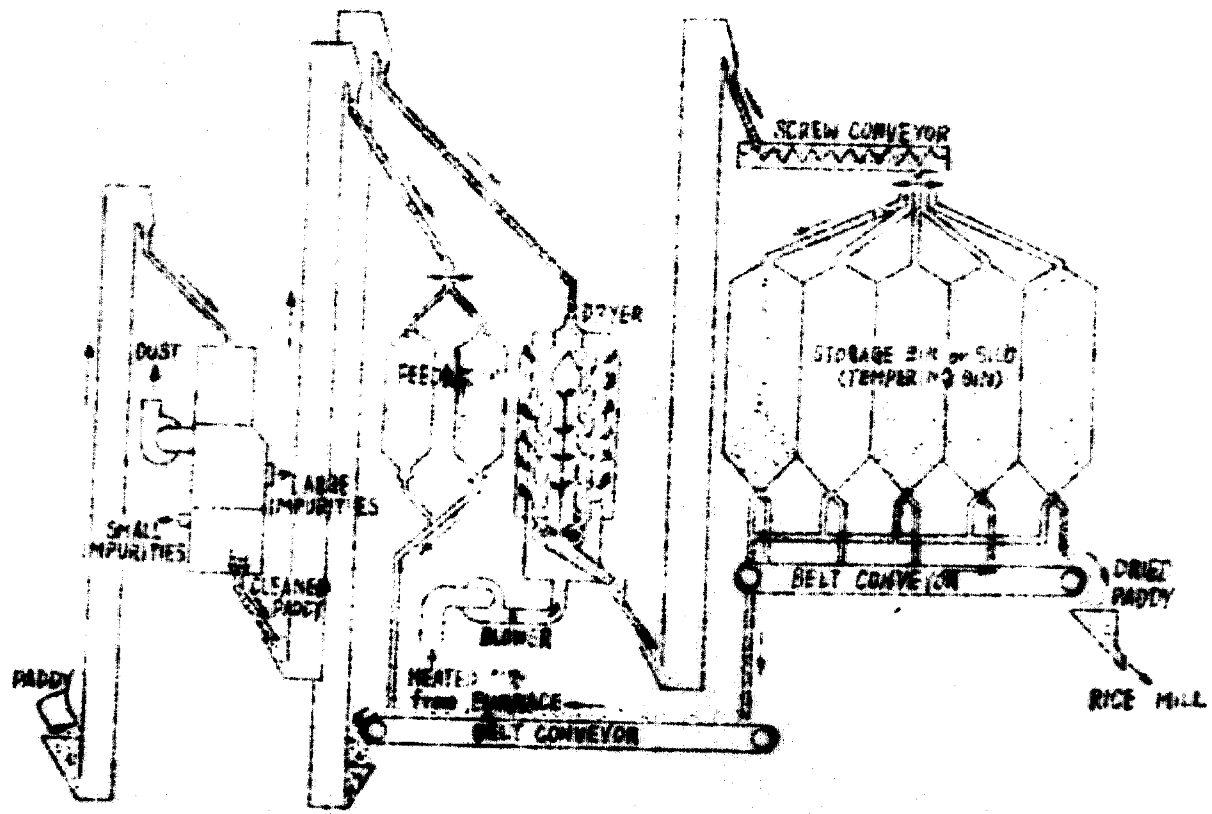


Fig. No. 2

FLOW CHART FOR TYPE-2 No.2004

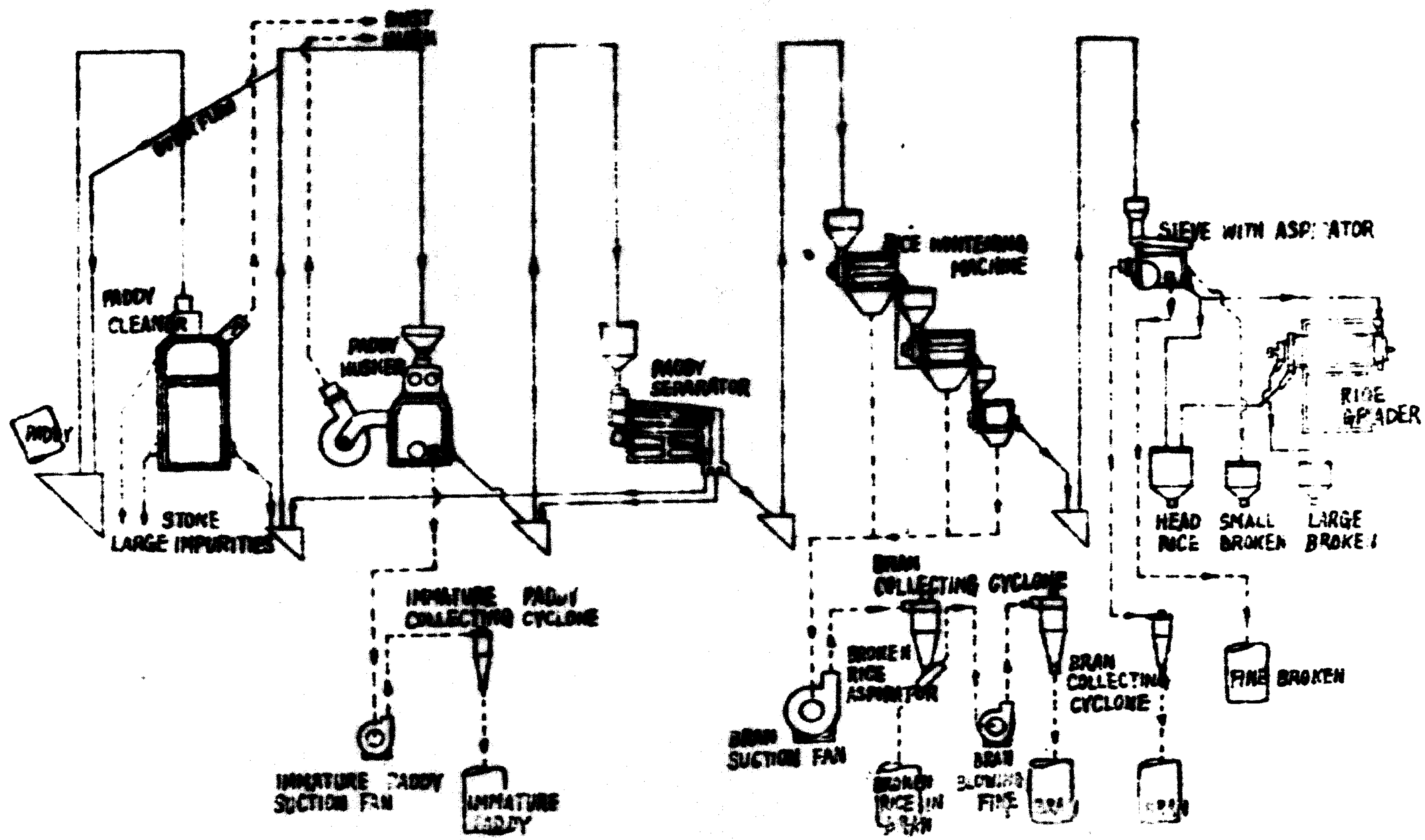
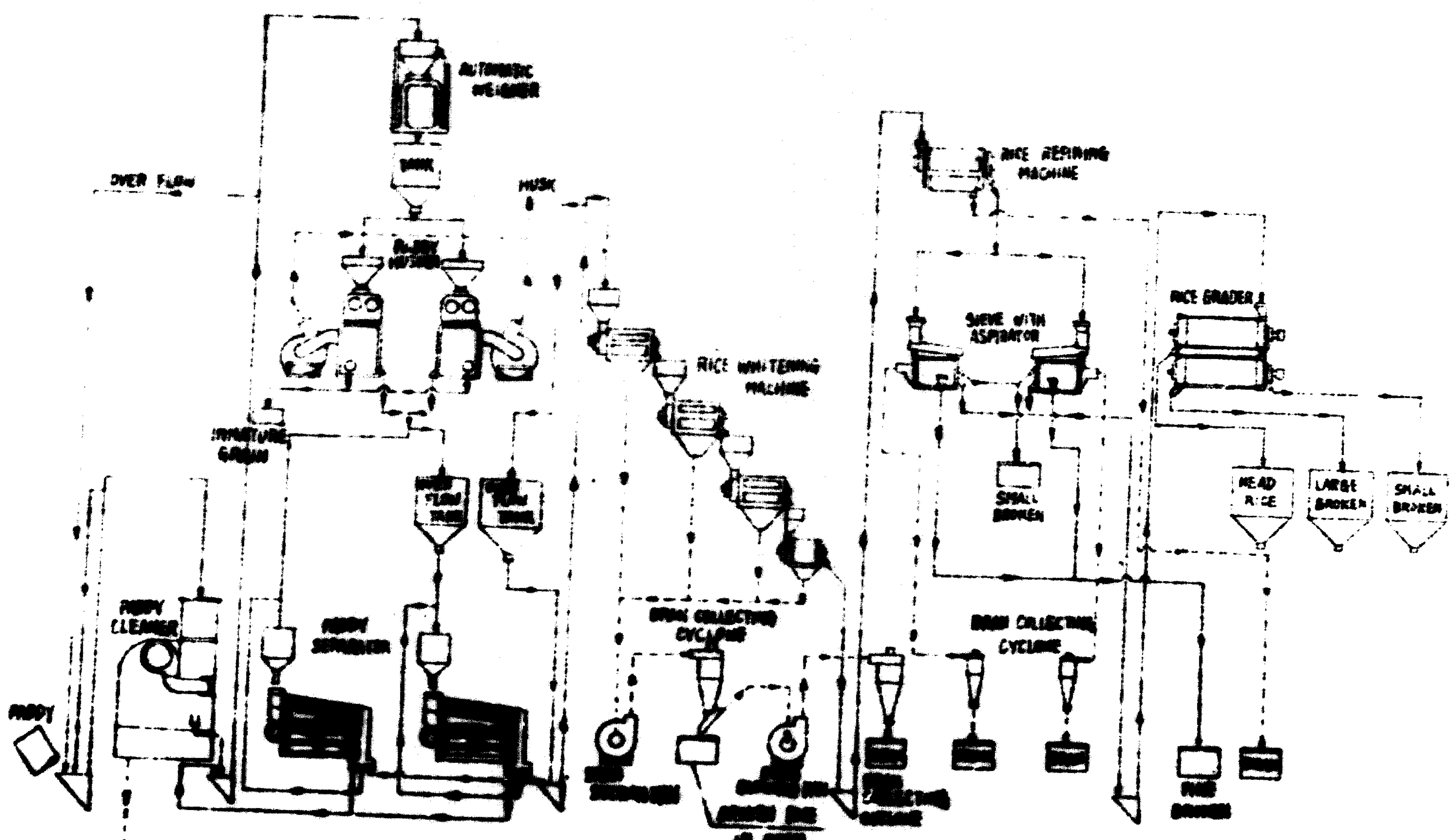


Fig. No. 3

FLOW CHART FOR TYPE-4 No. 4016



Miscellaneous data on rice-bran oil

1. Average oil-extraction ratio in Japan

Raw material (raw rice bran) as 100%.

By-products (broken rice and germ)	2 - 5 %
Extracted crude oil	17 -18.5%
De-oiled bran	74 -76 %

2. Composition of rice-bran

Water	Oil-content	Crude protein	Fibre	Ash
11-13%	18-21%	16-18%	8-10%	10-12%

Nitrogen-free extract
38-42%

3. Composition of de-oiled bran

Water	Residual oil	Crude protein	Fibre	Ash	Nitrogen free extract
10-12%	1.0-1.5%	17-20%	10-11%	10-13%	40-46%

In Japan 90% of de-oiled bran is used as feedstuff and about 10% as fertilisers for oranges, pears, apples, sweet potatoes and various vegetables. Composition is:

N (Total Nitrogen)	P (Phosphoric Acid)	K (Potassium)
2 - 3%	5%	1.5 - 2%

4. Refining of crude oil and use of refined oil

Extracted oil as source material	100%
(edible oil)	56-60% A.V. 0.5-0.8, Y25, R3.
Products (rice wax and fat wax)	10-20%, materials for wax.
(acid oil)	25-27% A.V. 110-125
Oil food	2 - 4%
Loss	3 - 5% in process.

5. Manufacturing Process

a. De-gumming

b. De-acidification

c. Washing

d. Bleaching by activated acid fuller's earth

e. De-odourization

f. Winterization

g. Filtering for finishing

6. Use of rice-bran oil

(A) Extracted Crude Oil

Toilet soap, washing soap, soap powder, fatty acid, vinyl-chloride placticiser and fatty acid ester.

(B) Finished Oil

Edible oil, salad oil, medicated oil and as source material for margarine.

(C) Wax

Furniture, floor and car wax. Ingredient in shoe polish and insulator of electrical wire/cable.
Source material for carbon paper, etc.

7. Composition of Rice Bran Oil: % of fatty acid

Oleic acid	34 - 45 %
Linoleic acid	30 - 40 %
Palmitic acid	13 - 15 %
Stearic acid	3 - 5 %
Wax	3 - 5 %
Orysanor (new vitamin)	2 - 3 %

Speciality:

A.V.	Low-acid oil	5-10-20-30
	Medium-acid oil	30-40
	High-acid oil	more than 50
I.V.	100 - 110	S.V. 175 - 190
Un Sm	6 - 8 %	
Specific gravity		0.91 - 0.92

Remarks: A.V. = acid value I.V. = iodine value
S V. = saponification value
Un Sm = Un-saponifiable matter

CHAPTER 2. STABILIZING PROCEDURE

Rice bran is subject to rapid lipase attack dependent upon the moisture content of the raw bran and the ambient temperature and humidity. The acid value or free fatty acid content rises accordingly.

When the acid value of the raw bran is 30 per cent or below, the oil must be extracted within three days of processing in warmer months of the year or within a week in the colder season.

The free fatty acid content of rice bran oil immediately after processing:
2 to 4 per cent in the case of a fresh crop;
5 to 8 per cent in the previous year's crop; and
10 per cent or more in the case of the crop of the year before that.

Generally, properly processed good-quality parboiled rice bran has a high oil content of some 18 to 24 per cent. In many instances its acid value is low (some 10 to 25 per cent) when lipase activity is suspended. However, rice-bran produced from rice that has been improperly handled and carelessly parboiled is affected by fermentation and the acid value is high, between 30 and 50 per cent.

Lipolysis can be inactivated by heat treatment at 100°C. for three minutes or at 85°C. for 5 - 7 minutes. At temperatures above 85°C. the moisture content of the bran drops to 3.0 to 4.0 per cent and the lipolytic enzymes are destroyed completely.

If the raw bran is dried at a low temperature of 50° to 60°C. to a moisture content of 3.0 per cent, the lipases are not destroyed but temporarily inactivated. Upon remoistening, lipase activity starts again and the acid value increases. Hence, to stabilize the bran for storage purposes, it should be steamed to a temperature of 90° or 95°C., then dry heated to reduce the moisture content to 3 to 4 per cent, followed by air cooling to remove the moisture. If stored in a cool place after this treatment, the bran will show no appreciable free fatty acid increase for a long time. Bran thus stabilized can be stored for about three months. However, it is preferable not to store for more than one month if the bran is to be used for oil-extraction purposes. If the bran is stored for two to three months after stabilization the oil extraction rate drops slightly and the oil yield is reduced by 1.0 to 2.0 per cent, while the oil obtained is a slightly darker shade.

The cost of stabilizing raw bran as above is approximately ¥1,000 per ton of bran, i.e. ¥30 per 30 Kg. bag with a weight reduction of 5 to 8 per

Assuming 30 Kg. bag bran = ¥600

30 Kg. x 5/100 x ¥20/Kg. + ¥30 = ¥60

Thus a 28.5 bag of stabilized bran costs: ¥600 + ¥60 = ¥660. The bra must be sold at more than ¥660 per bag, preferably with 20 per cent mark-up. At the moment, however, there is no stabilised bran on the market in Japan.

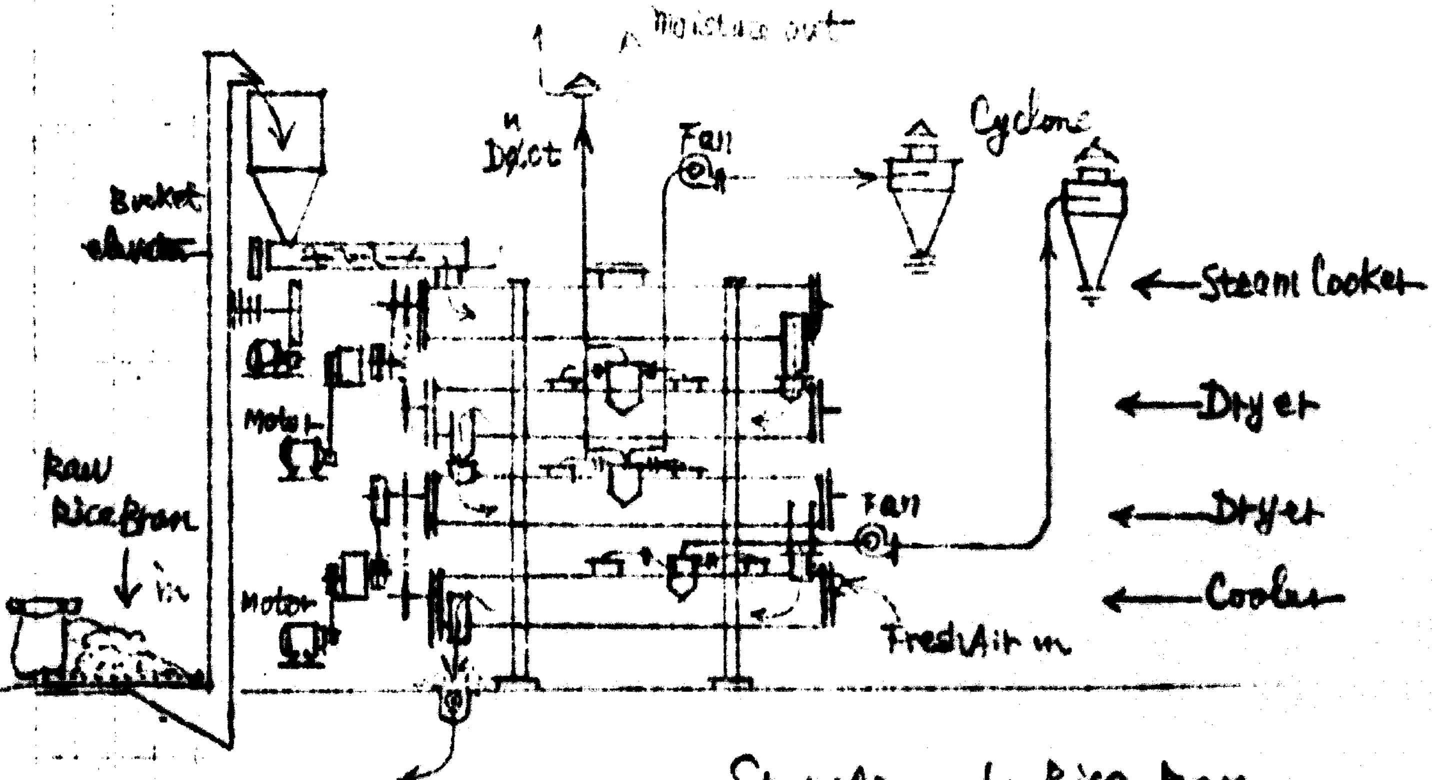
Stabilisation entails three stages:

(1) Steaming with direct steam injection.

(2) Drying using a steam jacket with a pressure of 4 to 5 Kg/cm² and updraught.

(3) Cooling using forced cold-air circulation from both ends of the dryer to ensure moisture removal.

The above stabiliser system is similar to the pre-treatment and heati unit used in batch-type solvent extraction.



Stabilizer for Rice Bran

Designed by K. [illegible] 1. June 1971.

CHAPTER 3. THE SOLVENT EXTRACTION PROCESS

The Preparation Process

Requirements for efficient solvent extraction of rice-bran oil.

Pre-treatment apparatus.

Steam cooking, drying and cooling.

Cooking and drying are two separate phases in the preparation of raw rice bran. The cooker must be large enough to hold rice-bran for 10 minutes at a temperature of 95 - 100°C, and a high constant moisture level is essential. Hence the cooker must be as vapour-tight as possible. Maximum exposure of each raw material particle to direct steam and moisture is required.

When drying, the rice bran must be kept at an adequate temperature for a minimum period of time to prevent heat damage to the oil and meal.

Cooling, the third step, is used for high temperature dried bran, and all moisture should be removed. 3.5 - 4.5% moisture content is best for batch-type solvent extraction, whereas a moisture content of 6 - 8% is better for certain continuous extraction systems.

Oil Extraction Methods

Two kinds of oil extraction methods, mechanical and solvent methods, have been practised for many years. The first method employs hydraulic presses to gradually press oil out of raw bran, the fibre of which has been softened through drying and steaming processes. Solvents, usually hexane, are used in the second method. The respective oil extraction rates are as follows:

	Extraction Rate	Pressure Per Sq.Inch
Mechanical	10-13%	1,000-4,000 lbs.
Solvent (hexane)	17-18%	

Since the World War II, solvent extraction has become increasingly popular in Japan and elsewhere, and numerous oil extraction plants are using this method. There are several categories of solvent extraction: batch-type, battery-type and continuous-type. However, batch-type extraction with three to six extractors (capacity 1.5 and 2.3m^3)respectively) or battery-type extraction employing four to six extractors (capacity 3m^3) prevail. Nevertheless, continuous extraction has many advantages and a few plants have already adopted this method, following further research and improvements in extraction methods.

Table 9. **Analysis**

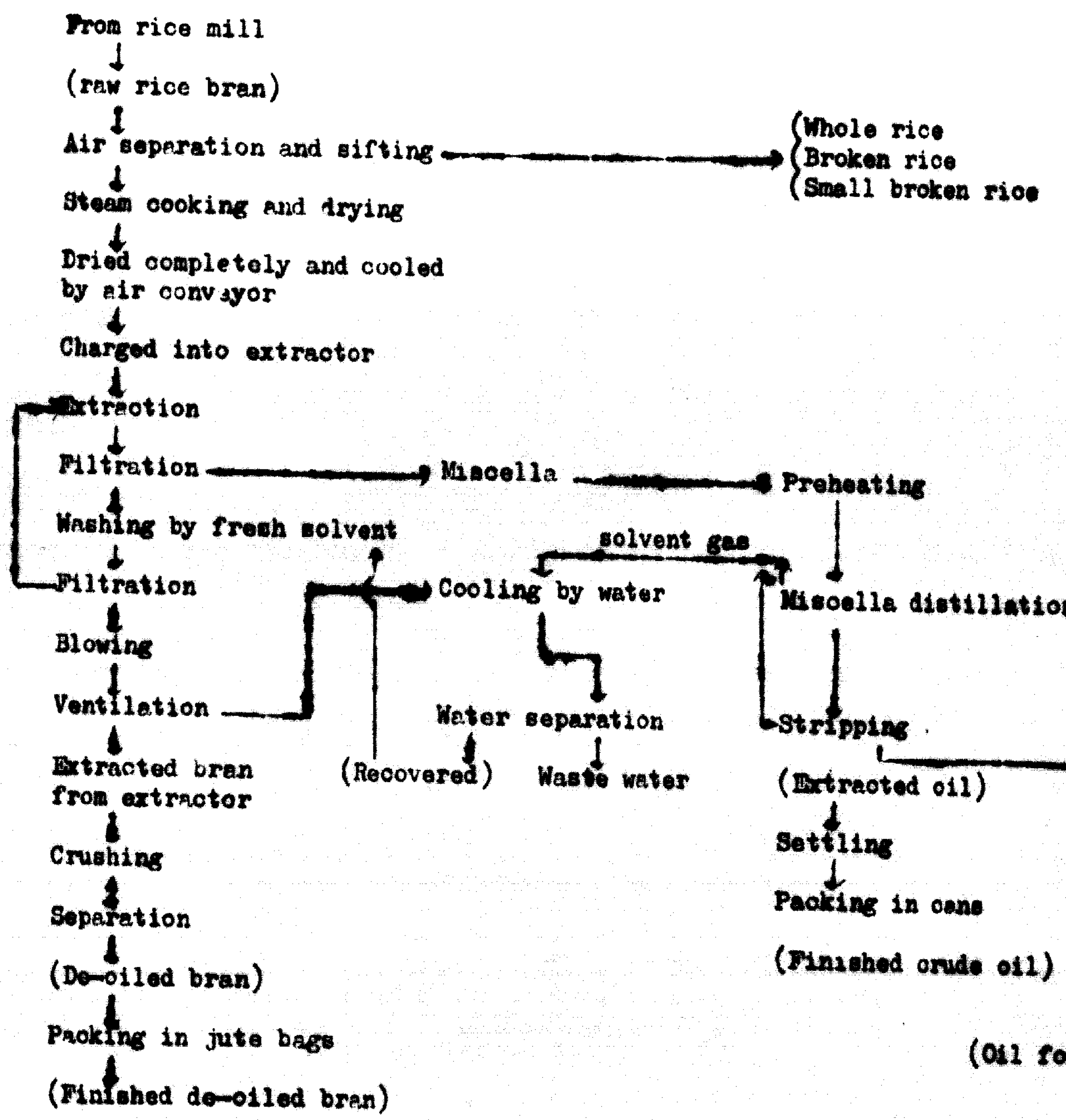
	Raw Bran	De-oiled Bran (pressed)	De-oiled Bran (extracted)
Water	12.59	9.39	12.28
Crude protein	13.31	16.07	17.31
Nitrogen (Total nitrogen	2.13	2.57	2.77
Nitrogen (Proteid N.	1.84	2.37	2.47
Nitrogen (Non-proteid N.	0.29	0.2	0.3
Crude fat	21.21	11.21	1.32
N-free extract	34.44	41.13	45.49
Fibre	10.05	10.79	11.59
Ash	9.40	11.41	12.01

Batch-Type Solvent Extraction

There are two major types of extraction unit: batch or battery type, and continuous type. The batch or battery type is suitable for the extraction of rice-bran oil; it also may be used for vegetable oil extraction. The continuous type, suitable for the extraction of vegetable oil, is used primarily for the production of oil from miscellaneous raw materials and meal. It may also be used for rice-bran oil extraction. Judging from conditions in Nepal and other countries, the batch-type extractor would seem suitable. The extraction process is as follows:

Table 10. Flow Chart of Rice-Bran Oil-Extraction Plant

(batch extraction: solvent — n-hexane, B.P. 66 - 70°C)



Rice-Bran Oil-Solvent Extraction Equipment Suitable for Batch-Type Operations

Yokochi System Rice-Bran Oil-Extraction Equipment incorporates many outstanding features ensuring advantageous extraction of high-grade oils from raw rice bran as well as the effective production of superior quality de-oiled bran. Nutritionally enriched edible oil with a wholesome flavour can also be derived.

Features of extraction system:

Most suitable system adaptable to effective separation of coarse and fine brans;

Appropriate cooking and drying processes for optimum pre-treatment of the raw material;

Batch-type extraction capable of dealing with all troublesome materials, including pulverized bran;

Unique filtering/cleaning facilities for effective removal of impurities in miscella;

Continuous supply of pure distillable miscella for the production of high-quality oil using film still;

Heat exchanger and preheater for steam economy;

Easily accessible condenser & cooler for operation and maintenance;

Multi-stage method ensures perfect dehydration and satisfactory solvent recovery;

Special solvent recovery system (cooler & oil absorbing tower) minimises solvent losses in exhaust gas;

Sanitary & efficient operation guaranteed throughout from continuous crusher, cleaning, hopper bin, automatic scales to final packing of meal;

Final products of guaranteed quality.

Rice Bran Extraction plant
Batch Type

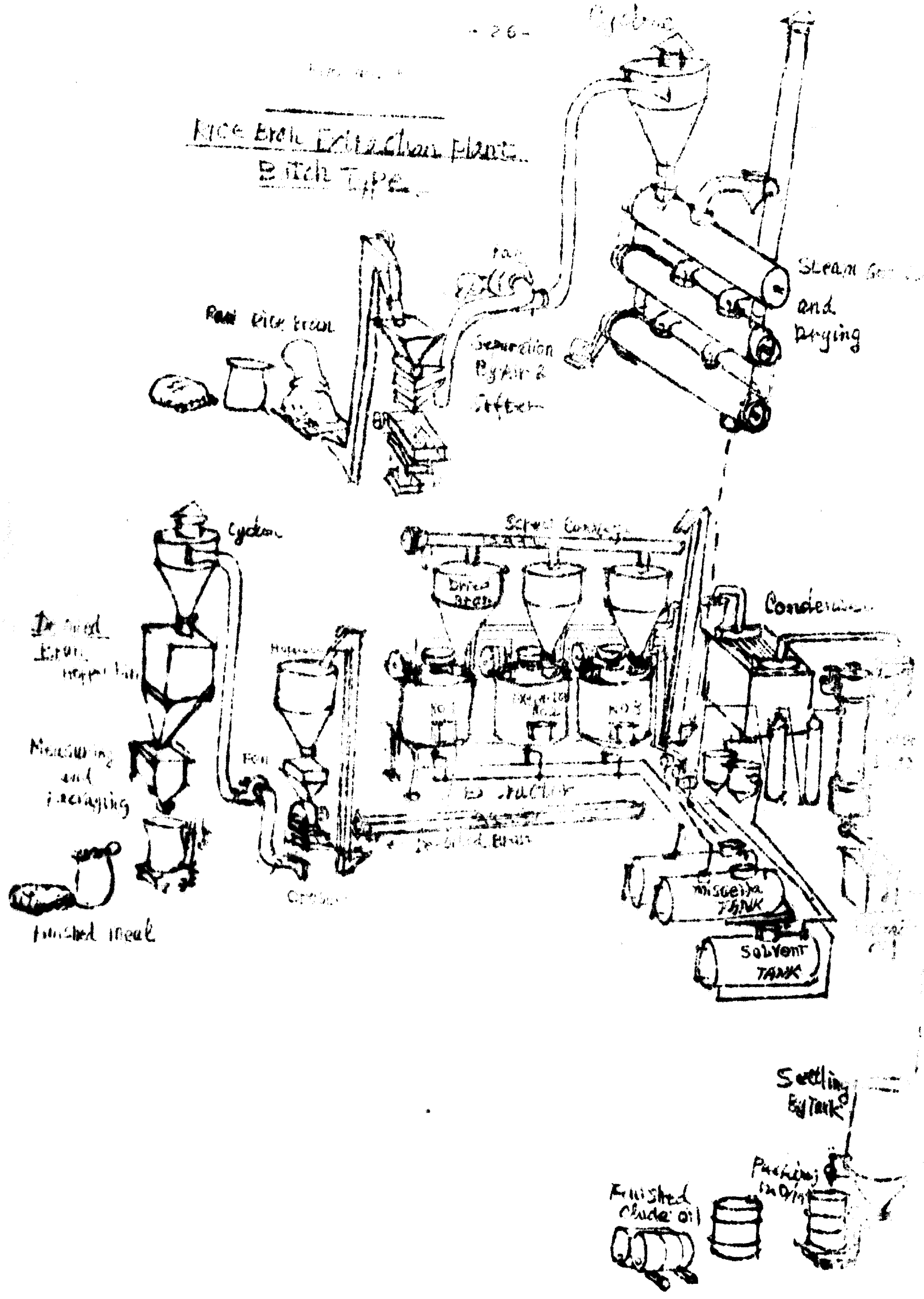


Fig. No. 6

BATCH SYSTEM 3 EXTRACTORS **RICE BRAN OIL EXTRACTION PLANT** CAPACITY : 12 TONS OF RICE BRAN PER 24 HOURS

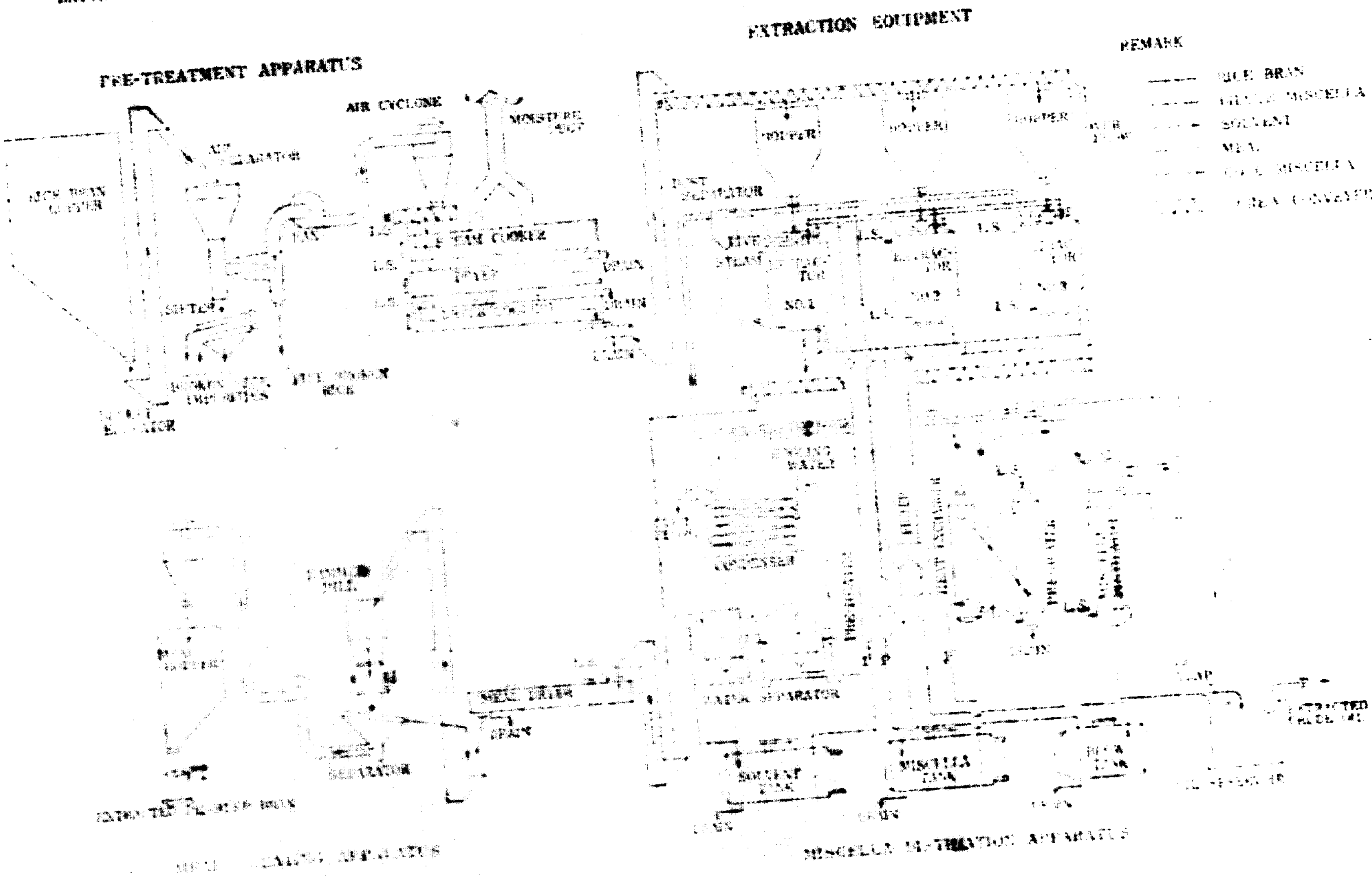
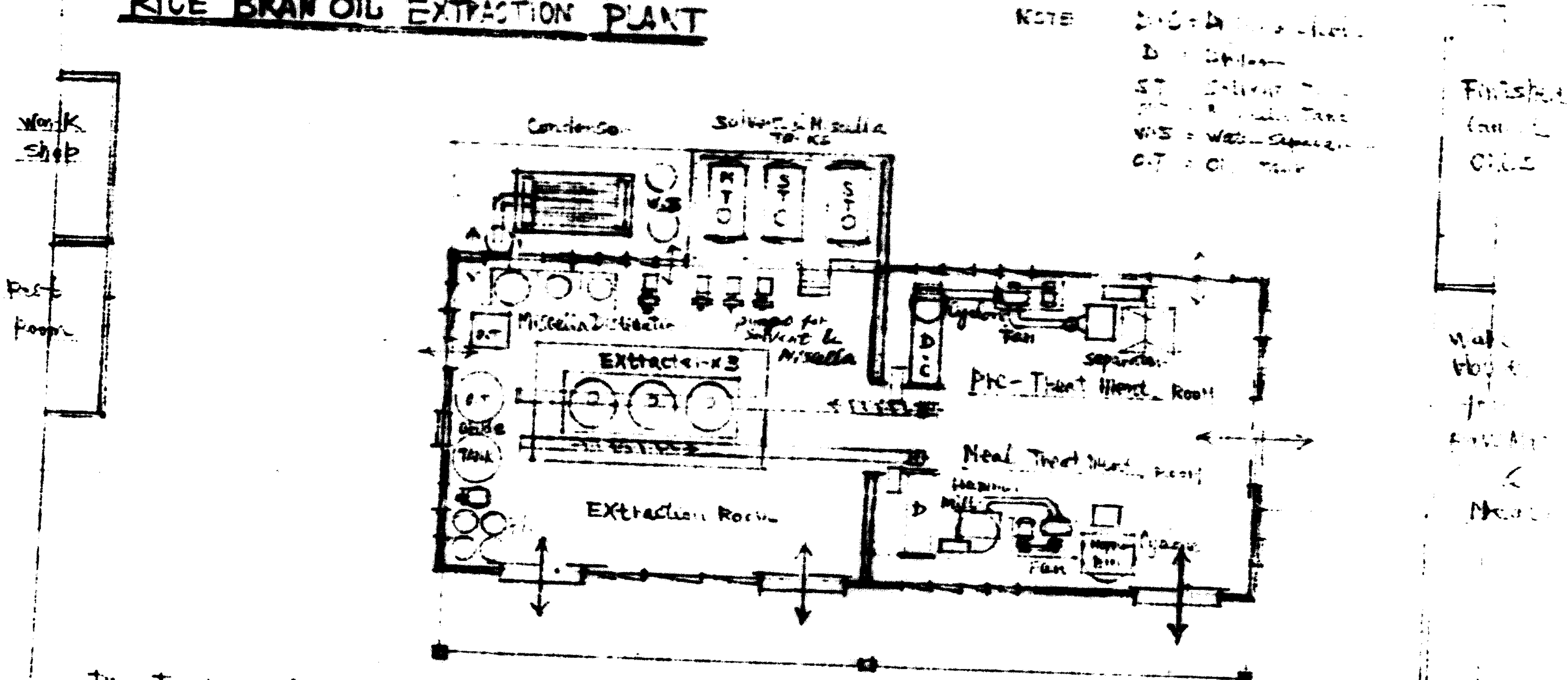


Fig. No. 7

RICE BRAN OIL EXTRACTION PLANT



Pre-Treatment Room. ... 11 M x 13 M = 143 M²

Rice Bran Separator	1 set
Fan. Cyclone	1
Dryer & Cooker	3

Meal Treatment Room.

Dryer.	1 set
Hammer mill. sifter.	1
Fan cyclone	1
Meal Hopper Bin	1

Extraction Room 11 M x 15 M = 165 M²

Screw Conveyor	2 set
Extractor 2 N 3	3
Gear pump	4
Solvent & Miscella Tank	2
Miscella still	1
Condenser	1
Water separator	2
Crude oil Tank	2

Features of Refining System:

Semi-continuous process suitable for refining rice-bran oil;

Greatly simplified process introducing de-gumming/de-waxing in initial stage;

Neutralization distilling method with effective separation of medium-acid oil (A.V. 40-60) into combined fatty acids and neutralized oil;

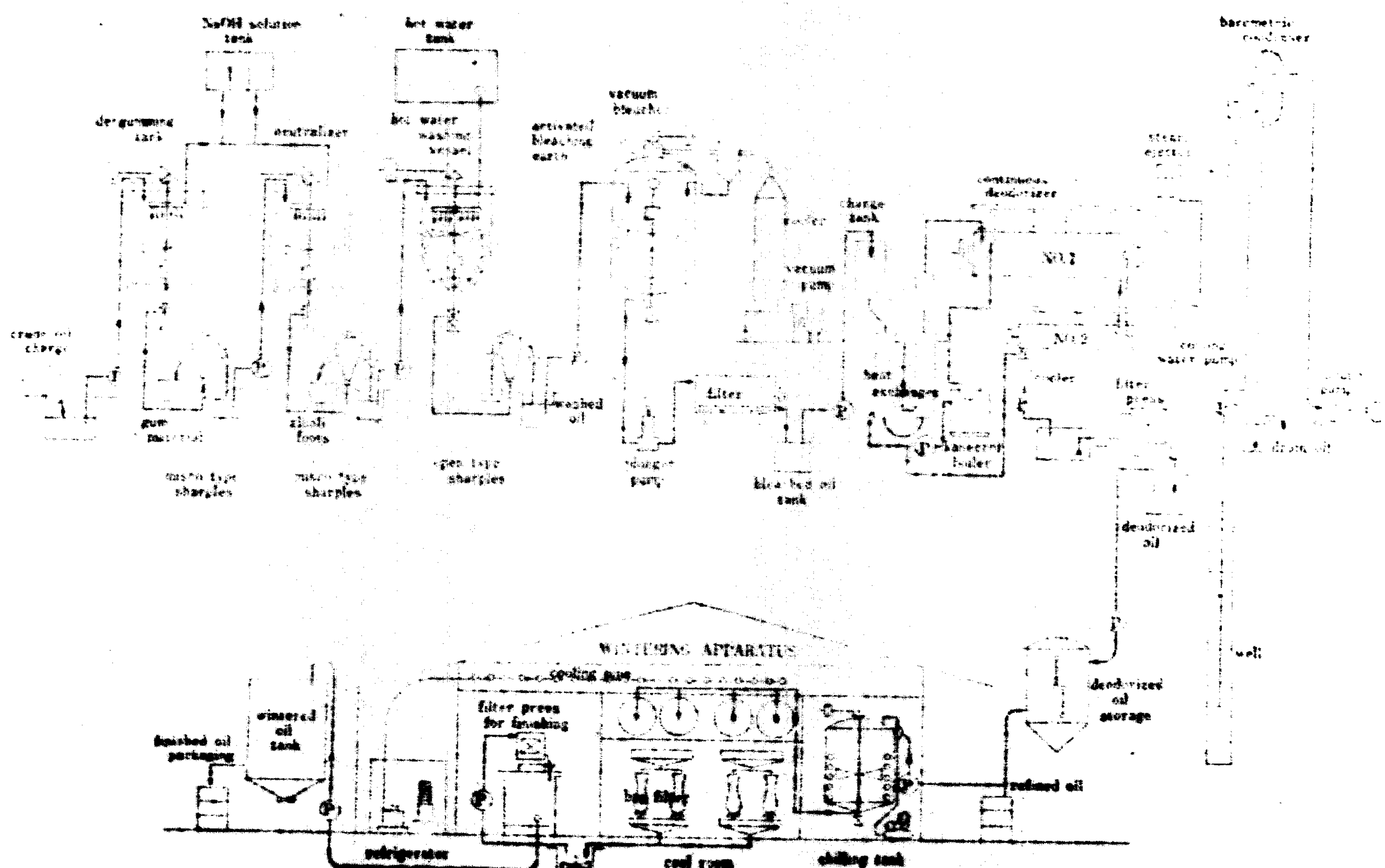
Neutralized and low-acid oil deoxidized semi-continuously with alkali and washed with water;

Vacuum bleaching;

Special continuous deodorization device for production of tasty edible oil from bleached oil;

Finishing/dewaxing process using fundamental low-temperature filter method.

Fig. No. 8 RICE-BRAN OIL REFINING PLANT



Extraction Capacity: Rice-Bran 6 ton/24H

Extraction and refining plants should be located in advantageous places to facilitate material procurement.

Materials required for extraction:

(1) **Solvent:**

Normal Hexane B.P. 66 - 70°C

1,500 - 2,000 litres/month (Normal hexane is the recommended solvent. Solvent loss is approximately 1.0% and residual oil in extracted meal is approximately 1.0% to 1.5%)

(2) **Lubricant:**

Gear oil, machine oil, spindle oil, dynamo oil, etc.

1.5 - 2 litres/month or about 20 litres/year.

(3) **Packing:**

Super graphited packing (little quantity)

Asbestos thread packing (little quantity)

Asbestos plate packing (little quantity)

(4) **Spare parts:**

1 small quantity of pipes, valves, cocks, couplings etc., must be stocked: diameters ranging 1", 1-¼", 1-½", 2", 2-½" and 3".

(5) **Fuel:**

Heavy oil B for extraction boiler:

50 litres/ton rice bran or [illegible],500-6,000 litres/month.

For combined oil-refining and extraction operations:

85 litres/ton of rice bran or 12,750 litres/month.

Heavy oil is not required, if husk is used as fuel source.

(6) Electric power requirement:

25-28 KWH/ton raw rice bran. If 150 tons raw rice-bran are processed monthly, power requirements are 4,200 KWH.

Extraction system	:	1 set - 30 KWH
Refining system	:	1 set - 30 KWH
Electric light	:	1 set - 10 KWH

33 V supply is to be stepped down to 220V for use as electric power and to 120V for use as electric light.

<u>Profitability of batch-type extraction plant in Japan</u> (Capacity: 900 metric tons bran/month)

(1) **Basic data**

Extraction yield:	Crude oil	17%
	De-oiled bran	75%
	Broken rice	2%
Refined Oil Yield: (Crude oil)	A.V. 25 Edible oil	62%
	A.V. 120 Dark oil	25%
	A.V. 8 Wax oil	8%
Price:	Rice Bran	¥650/30Kg.
	De-oiled bran	550/25 "
	Broken rice	1,700/80 "
	Edible oil	23,000/dm (200 litre 181.5 kg)
	Dark oil	7,000/dm "
	Wax oil	6,000/dm "
	Fatty oil	18,000/dm "

(2) Expenditure per month.

Raw material	¥650/30Kg x 30,000 bags	¥19,500,000
Solvent: litre/ton of bran	0.95%, ¥35/l x 8,550 l =	299,250
Refining material:	¥520/dm x 841dm =	437,320
Fuel:	85.? l/ton ¥10/l l =	767,500
Power consumption:		110,000
Labour:	¥50,000 per person x 40 persons=	2,000,000
Other expenses:		1,300,000
Interest: Fixed ¥30,000,000 x 0.75% (9.25% year)		225,000
for material: 39,000,000 x 0.75%		292,500
Others (dividends, bonus, taxes, repair & maintenance costs, sales expenses, transportation costs and reserves)		800,000
	Total Amount	¥26,231,570

(3) Income

153 M/T (17%) of crude oil produced from 900 metric tons raw rice-bran amounting to 841.5 drums (1 metric ton = 5.5 drums).

Each drum contains the following ingredients:

Edible oil	¥23,000/dm x 62% =	¥14,260
Dark oil	7,000/dm x 25% =	1,750
Wax oil	6,000/dm x 8% =	480
	Finished product value per drum	¥16,490

¥16,490 x 841 drums = ¥13,868,090

De-oiled bran:	900 ton x 75/5% = 679.5 ton x ¥22,000 =	¥14,949,000
	(¥550/25Kg = ¥22,000 per ton)	
Broken rice:	900 ton x 2% = 18 ton x ¥21,500 =	382,500
	(¥1,700/80Kg = ¥21,250 per ton)	
Empty bags:	¥8 x 2,500 =	200,000
	Total income:	¥28,399,590

(4) Profit

¥28,399,590 - 26,231,570 = **¥2,168,020**

(5) Numbers of Employees Necessary for Operation

Type of work	Male	Female	Night Shift	Remarks
Office work	1	2		
Sales activity	2			
Warehouse keeping	3			
Preliminary treatment	3		2	
Extract work	4		4	
Boiler-man	1		1	
Packing	2		2	
Transportation	6			
Refining work	4		2	
Engineers	2			(Mechanical Engineer 1 (Chemical Engineer 1
Others	1			
Directors	4			(President 1 (Executive Director (Business) 1 (Executive Director (Engineer) 1 (Other (Accounting) 1

Continuous solvent extraction

A modernised oil-production plant using the expeller and continuous extraction equipment can process all kinds of raw material for fats and oils.

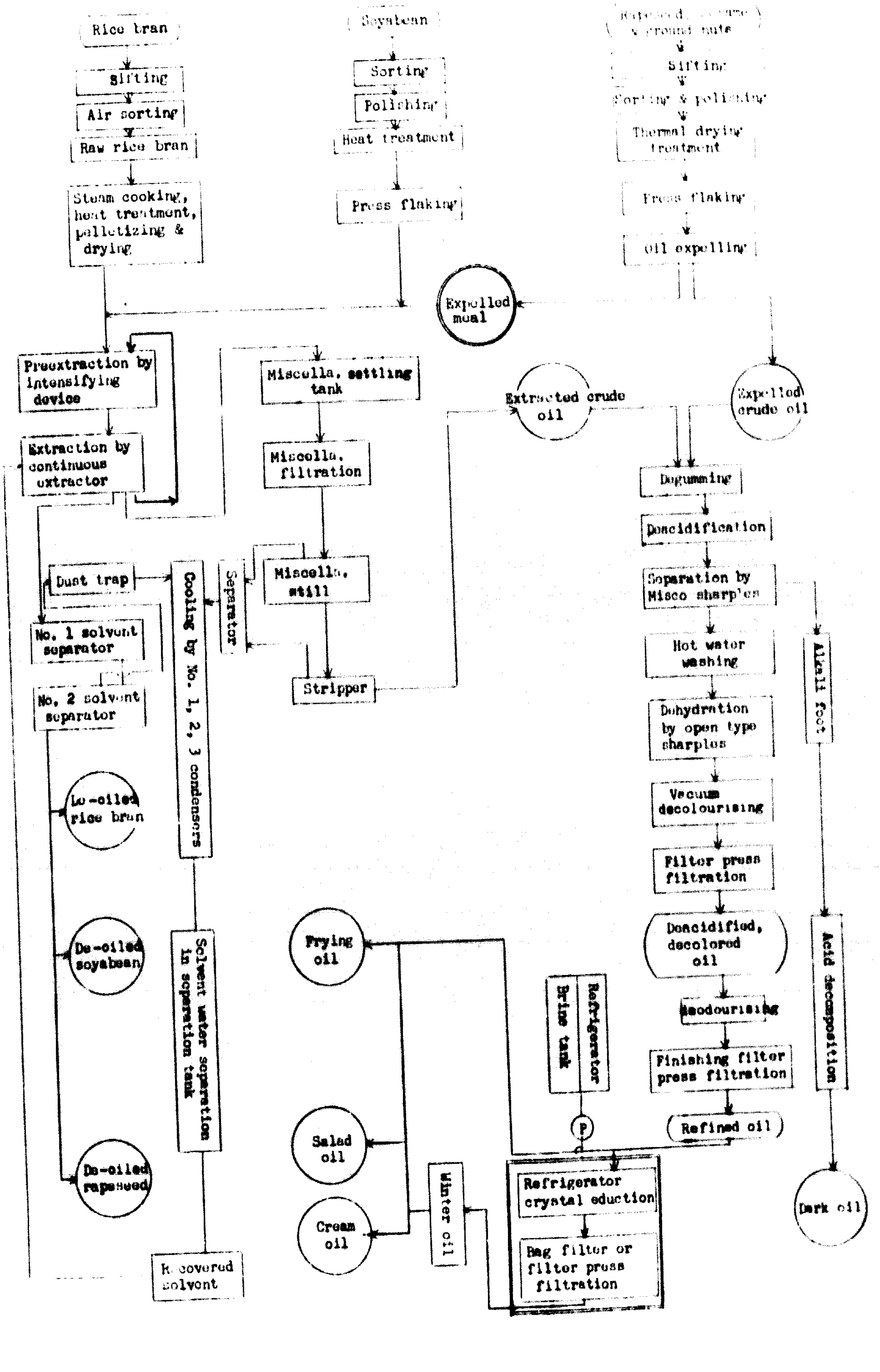
This holds true for the continuous extractor producing rice-bran oil, which is highly valued on account of its development potential.

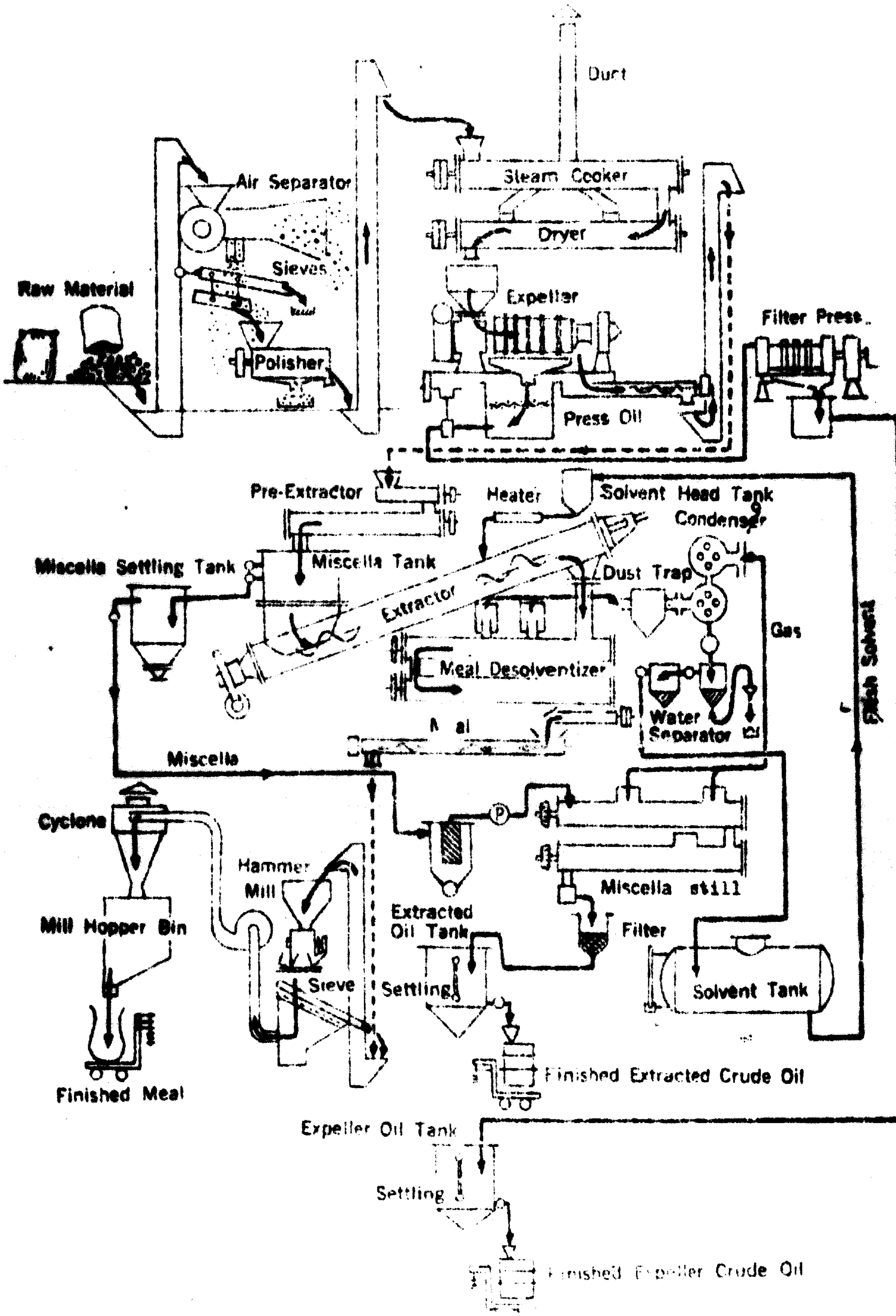
Essentially, a continuous extractor, by virtue of its construction, is sai to be unsuitable for raw material such as rice bran which has a powdery structu containing fine particles. However, given proper pre-treatment of the raw material, extraction is not only possible but also efficient.

When extracting rice-bran continuously, for example, it is necessary to pre-treat the rice-bran with special steam-heating, cooking, drying, and press into pellets holding the particles of powder. After pre-treatment and extract the minute floating particles in the extracted miscella settle in the settling tank. Whereafter the miscella is completely filtered and purified in a specia filtering apparatus before being distilled. Rice-bran oil-extraction is possi using an improved continuous extractor, which can be converted for rice-bran extraction.

Process Chart of Oil Expelling & Extraction and Refining **According to Raw Material**

Fig. No. 9




Duct
Air Separator
Steam Cooker
Dryer
Sieves
Raw Material
Expeller
Filter Press
Polisher
Press Oil
Pre-Extractor
Heater
Solvent Head Tank
Condenser
Miscella Settling Tank
Miscella Tank
Extractor
Dust Trap
Gas
Meal Desolventizer
Fresh Solvent
Water Separator
Miscella
Cyclone
Hammer Mill
Miscella still
Extracted Oil Tank
Mill Hopper Bin
Filter
Sieve
Settling
Solvent Tank
Finished Extracted Crude Oil
Finished Meal
Expeller Oil Tank
Settling
Finished Expeller Crude Oil

Suitable Equipment for Continuous Solvent Extraction

Process Chart of Continuous Extraction System

Solvent used: Normal Hexane B.P. 66-70 °C

Table 11. Flow sheet of Rice Bran Extraction Plant

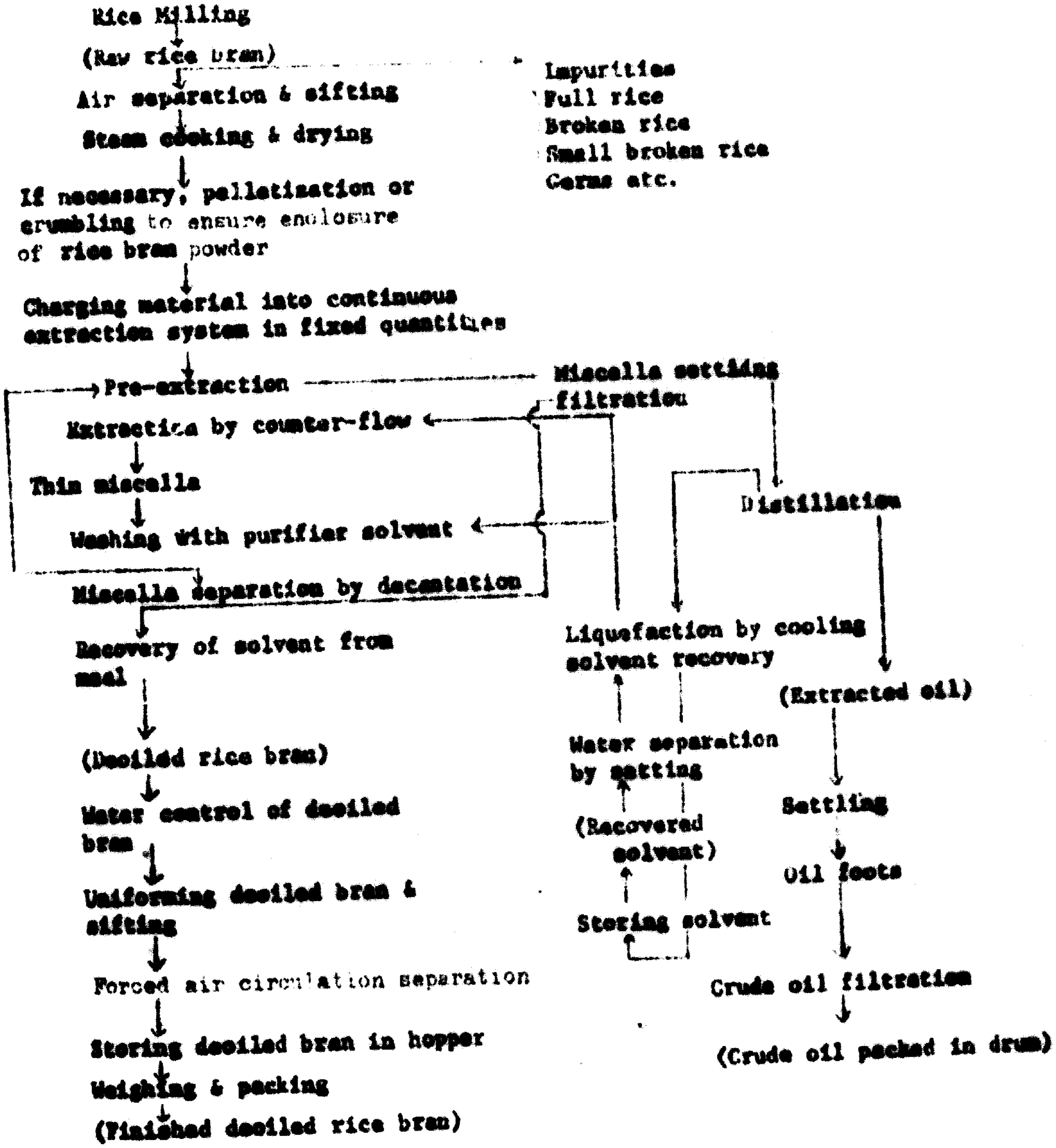
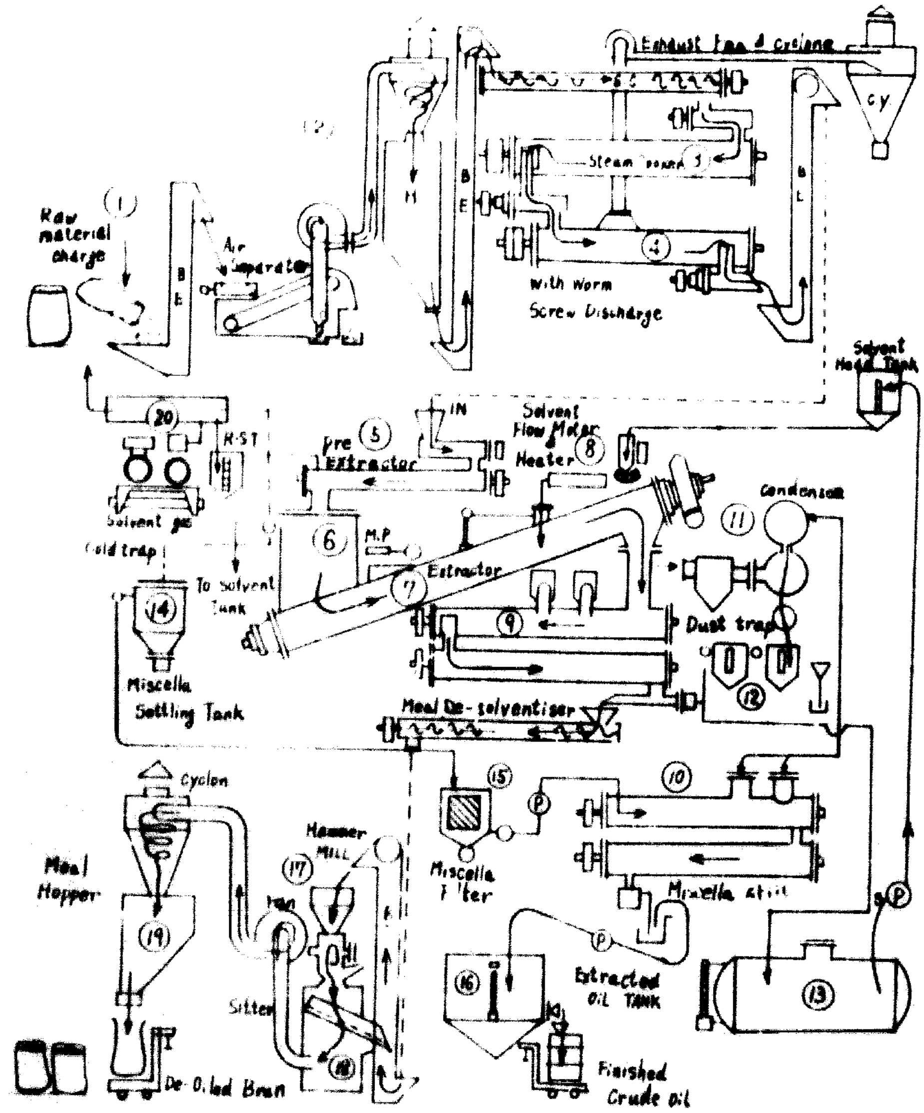


Fig. [illegible] **Flow diagram for continuous extraction system**

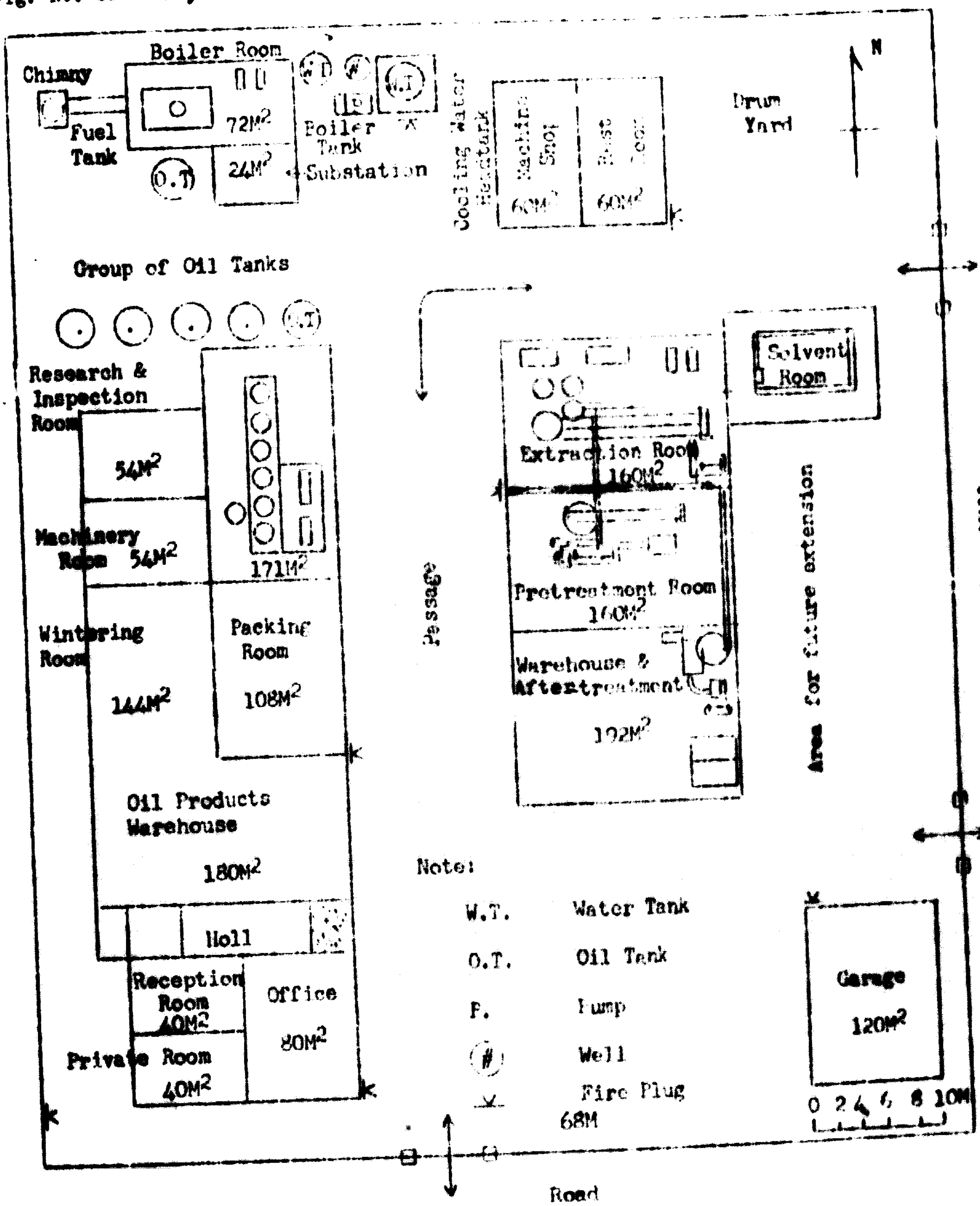


Names of Extraction System Machinery & Devices:

1	Raw material charge
2	Air separator, fan, cyclone & hopper
3	Steam cooker
	Dryer
5	Extraction intensifying device
6	Miscella, tank
7	Extractor cylinder
8	Solvent flow meter & heater
9	Meal desolventizer
10	Miscella, distiller
11	Dust trap & condenser
12	Solvent water separator
13	Solvent tank
14	Miscella, settling tank
15	Miscella, filter
16	Extracted oil tank
17	Hammer mill
18	Meal sifter, air transmitting system
19	Meal hopper
20	Solvent gas cold trap

B.E.	Bucket elevator
H.	Hopper
c.y.	Cyclone
S.P.	Solvent pump
M.P.	Miscella, pump
R.S.T.	Recovered solvent tank
S.C.	Screw conveyor

Fig. No. 12 Layout of Rice-Bran Oil Extraction Plant



Advantages and Disadvantages of Batch-Type Extraction Plant and Continuous Extraction Plant

Batch-Type Solvent Extraction	Continuous Extraction
(1) Plant operation is troublesome, for example, valves have to be opened and closed at least ten times for each extraction operation. If extraction is done six times a day using six drums, valves will be operated 10 x 6 x 6 = 360 times. Failure to do so may result in an accident; accidents of an explosive nature also occur.	(1) If the plant is adjusted properly, it can be run continuously for hours without any additional work. If maintained in normal working condition, the machine seldom causes accidents; accidents of an explosive nature scarcely occur.
(2) Several workers are required for the extracting operation. At least three workers are necessary: one to operate the valve, one to change the material and one to process the meal. Labour costs are high.	(2) One watch man is sufficient as the machine is automatically operated. Labour costs are low.
(3) High running costs High steam consumption High steam pressure: 5-6 Kg/cm^2 required. Water required to cool solvent gas. Low power consumption: 20-25 KW/ton raw bran.	(3) Low running costs Low steam consumption Low steam pressure: 3-4 Kg/cm^2
(4) The meal has a greater part of its protein transformed into a water insoluble state because of the large amount of steam injected to remove the solvent.	(4) Solvent removal of the meal is carried out by indirect steam heating, hence the protein in the meal is scarcely affected and in greater part remains in a water soluble state.

(5) The amount of oil left unextracted in the meal varies greatly with the material and, particularly, with the extraotion technique.
0.8 to 2.0-3.0 %

(5) The residual oil is scarcely affected by the extraction technique. Though not great, it is difficult to reduce it to a very small amount.

(6) The process is suited for rice-bran processing but oftem involves difficulties in extracting miscellaneous materials and requires training the operators.

(6) Suitable for processing miscellaneous materials but requires some sort of pre-treatment in the case of rice-bran oil extraction, e.g. pelletizing the rice bran.

(7) Depending on the kind of material, extraction becomes very difficult, requiring special techniques and resulting in variable product quality.

(7) With the material fed, the meal produced continuously is of uniform quality.

(8) Simple mechanical construction with few rotary parts involves little mechanical troubles. Solvent loss is small.

(8) Construction is complex and includes many rotary parts making proper maintenance necessary, without which solvent losses increase.

(9) The initial cost of plant installation is rather cheap, being less than two-thirds of the continuous type.

(9) Plant equipment is generally expensive.

(10) The batch system is preferably employed where the transportation of machines is difficult, labour requirements are readily satisfied, and special extraction engineers are available.

(10) The continuous system may be employed where substantial investment funds are available for equipment. A repair shop, at least, should be available and plant location should permit transportation of the machines.

(11) Operation techniques must be acquired. When operated by a skilled engineer, very good results can be obtained. Operation by an unskilled operator is disadvantageous in every respect.

(11) The performance of the extraction equipment is determined by machine design, operation techniques, and the range of products. The operator merely has to switch on the machine and keep a check on the operation as required. The result is not dependent on the skill of the operator.

(12) In summary, the batch system of rice-bran oil extraction is recommended where capital investment economies are desired, a skilled engineer is available for operation control; and the plant site selected is rather inconvenient with no repair shop available in the neighbourhood; as well as there being readily available labour (relatively speaking).

(12) In view of the above, a continuous system is preferable where there is plenty of investment capital available; a variety of materials, including rice bran, is to be processed, a repair shop is located in the vicinity, the plant is situated near a city where labour cost is high, and the manager has progressive views on work.

CHAPTER 4. RICE BRAN OIL UTILIZATION AND REFINING

Composition and characteristics

Crude oil contains waxes and a small amount of gummy proteinaceous matter, starch, water, etc. which should be removed. It is a clear oil which smells like rice flour. Low-acid oil produced from fresh material is yellow-green in colour but turns increasingly brown as the acid values increase, whilst an oil with a high acid-value assumes a dark brownish purple colour.

(N.B. Acid values in crude oil : 5 to 120, average 20 - 40)

(1) Chemical characteristics of rice-bran oil

Classification	: Semi-dry oil
Specific gravity	: 0.912-0.927 (15°C)
Refraction index	: 1.465-1.467 (40°C)
Saponification value	: 175-190
Iodine value	: 92-115
Henel value	: 92.1-96.5
R.M.V.	: 0.59-1.75
Unsaponifiable matter	: 3.0-8.0%
Calories	: 9.438
Acid value	: 5-120

(2) Composition of fatty acids

Palmitic acid	: 13-18
Stearic acid	: 1-3
Myristic acid	: 0.1-1
Oleic acid	: 40-50
Linoleic acid	: 20-42
Linolenic acid	: 0-1

(3) Characteristic of rice-bran oil fatty acids

Melting point	: 30-45°C
Specific gravity	: 0.89892-0.9063 (15°C)
Neutralization value	: 190.47-195.09
Iodine value	: 104.62-112.35

(4) Unsaponifiable matter

Besides the above, 5-10 per cent of unsaponifiable matter are waxes, vitamin E, oryzanol and squalene contained in rice-bran oil.

(5) Remarks

A characteristic feature of rice-bran oil is the presence of 2-4% pure wax with a high melting point, which is not to be found among other types of oil. The oil cannot be used for edible or industrial purposes until the wax has been removed. However, the wax is reported to be a useful high M.P. Wax (M.P. 72 to 84°C) for industrial, cosmetic and edible purposes if extracted in a refined, pure and decolourized condition.

*Oryzanol

One of the unsaponifiable ingredients of rice-bran oil identified by Dr. Tomotaro Tsuchiya of the Government Chemical & Industrial Research Institute, Tokyo, and named after the paddy Oryzasativa.L. It shows maximum ultraviolet absorption spectrum under 230m/n and 315m/n, and the melting point is between 137.5 and 138°C. It is composed of several kinds of ferulic acids (4-hydroxy-3Ometoxy cinnamic acid) and contains 2 to 3 per cent crude oil. Rice-bran oil is an exception and also contains oryzanol. This has a marvellous effect similar to vitamin E in accelerating human growth, alleviating blood circulation and consequently stimulating hormonal secretion. It is easily extracted in crystal form, from which a new medicine called Oz has been recently developed.

Under these circumstances, mass-production of Oryzanol will be realisable in the near future and considerable amounts of it may come to be fed to livestock and fish.

*Tocopherol (Vitamin E)

Tocopherol is one of the oil-soluble vitamins in rice-bran oil closely related to the internal secretion of hormones. It, too, is regarded as a valuable source for the sustenance of human/animal life. Lately, the scientists in the U.S.S.R. have proclaimed it to be a nutritive agent for the brain as well as a valuable vitamin that maintains proper balance in the nervous system.

It is unsaponifiable and an important anti-oxydant. The tocopherol content in crude oil is 2-4 per cent and despite the 2.3% loss in the deodorizing process it remains in edible oils. Tocopherol is a distinctive feature of rice-bran oil; it provides nutritive value and strengthens anti-oxydant activity.

Squalene

Compositionally, a substance similar to calotin, $C_{30}H_{50}$. It is found in abundance in the shark's liver oil (squalidae = cat sharks) over 50%, but in crude rice-bran oil there is only 2 to 3 per cent.

Upon ingestion squalene has a noticeable effect pharmaceutically. It is especially efficacious against skin diseases and it is also believed to be a remedy for tuberculosis.

It is an important feature of rice-bran oil that it contains effective ingredients as oryzanol, vitamin E and squalene, and their utilisation is an important task for the future.

The various applications of rice-bran oil

A. Summary

Crude oil	:	Source material for soaps, fatty acids and miscellaneous industrial applications;
Semi-ref ned oil	:	Source me erial for soaps, fatty acids and various industrial applications;
Refined oil	:	For cooking oil, pharmaceutical and cosmetic applications.

Refined rice-bran oil is a clear, light-coloured, odourless, low-viscosity oil with a slightly sweet taste. Consequently, it is in great demand as cooking oil, frying oil, salad oil and as a raw material source for margarine. On the other hand, its main industrial applications are for the production of fatty acids, stearic acids, oleic acids, glycerine and soaps (particularly soap powder).

B. Rice-bran oil for synthetic fibres

Toyo Koatsu Industries, Inc., Japan, have recently completed a successful trial production of a new kind of tough fibre using rice-bran oil and urea resin. Named Yuriron, it is a hard-wearing and attractive fibre which can be used for various textiles, nets and ropes. Its resistance to salt water is outstanding, making it most suitable for fishing nets. Nevertheless, the lack of rice-bran in absolute quantities has prevented its industrialization.

C. Rice-bran oil for vinyl-chloride placticizer

Rice-bran oil has a new use as a raw material source for vinyl-chloride placticizer. D.O.P., T.C.P. or other plasticizing esters are mixed with poly-vinyl powder, a ratio 1:2. The mixed material is worked up to about 16°C using rollers, giving an elastic plastic substance which can be manufactured into electric cable covers, bands, sheets and vinyl cloth for agricultural use. For making such plasticizers, esterified rice-bran oil has been used because it is cheaper - approx. 1/2 to 1/3 of the oils' used hitherto - and its oleic acid content softens the vinyl-chloride obtained and balances it in relation to the fatty acid content.

Thus esterified or otherwise treated rice-bran oil has an ever-increasing number of applications and is also a raw material source for high-grade cutting oils. Distilled esterified rice-bran oil is also used in cosmetics and in hair-tonics. Furthermore, industrial research is being directed towards the reaction of high free fatty acid compounds with glycerine to produce glycerides which may be useful as edible oils. These are indicative of the changes in the conventional processing or use of rice bran oil, and the future of extraction, refining and other processing of rice-bran oil.

Refining rice-bran oil and its products

A. Summary

Crude oil	:	Extracted oil in its natural state produced via mechanical and/or solvent extraction method.
Filtered oil	:	Oil filtered through cloth or decanted from crude oil.

Refined oil : Clear light-coloured oil with low free fatty acid content remaining after neutralization and after pigments as well as fatty acids have been removed.

Rice-bran wax : High melting point waxes separated from rice-bran oil. Extraction is effected at a temperature slightly higher than the normal one at which hard waxes begin melting.

Alkali foots oil : Saponified product from alkali neutralization.

De-waxed oil : Oil filtered from refined oil which has been subjected to low-temperature wintering process. (Wax content in rice-bran oil is much more abundant than in other vegetable oils.)

B. Refining process of rice-bran oil

(1) The refining of rice-bran oil to produce vegetable oil is considered most difficult. Refining equipment must be perfect and highly efficient. It is designed exclusively for rice-bran refining on the basis of empirical data. The alkali refining method described in figure 13 guarantees most satisfactory production in the light of prevailing conditions. Alkali foots are removed by misco-type super-centrifuge. An open-type super-centrifuge is used for washing and a vacuum bleacher is used to remove oil pigmentation. Oil odour is removed in a double batch-type de-odorizing tank (inner tank is stainless steel), while for cooling purposes, a multi-pipe cooler is used. It is the safest formula for bran-oil production.

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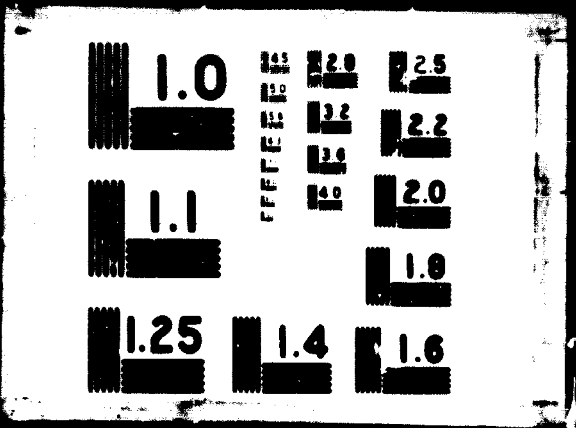


(2) Refining process chart

The refining process, which is directly connected to the extraction plant, is as follows:

Table 12.

Refining Process of Rice Bran Oil

Crude rice bran oil (100%) acid value 30

↓

De-gumming and preliminary de-waxing

↓

Separation by Misco-type super-centrifuge

(Yield gum and crude wax 4 - 6%)

↓

De-acidification by alkali

↓

Separation of alkali foots by Misco super-centrifuge → (Dark oil) 20-30% fat acid and soap material

(neutralized oil)

↓

First washing by water

↓

Second washing by warm water

↓

Third washing by warm water

↓

Separation of warm washing water by settling

↓

Removal of warm water by open super-centrifuge

↓

Vacuum bleaching

↓

Filteration by press

(Bleached oil)

↓

De-odorization

↓

Continuous cooling

↓

Filtration by press

↓

Refined oil (edible oil), yield 64-68%

↓

De-waxing by cooling

↓

Filtration by bag filter / (cream oil) 8-10%

Room temp. plus 5 - 8°C

↓

Filtration by press (Finished oil)

↓

(Winter oil)

High-class edible or salad oil

Yield 56 - 58%

(3) <u>Modern refining system</u>

There is a modern system called the distillatory deacidification method, which requires high temperature levels and a highly vacuous condition for processing. However, only a few plants have adopted this new method and almost all plants now in operation are practising the alkali deacidification or bleached clay de-colourization/refining systems used hitherto. Care must be taken to absolute accuracy of the de-odorization/de-waxing process.

- The acid value (A.V.) is 30.
- 0.1 - 0.3% phosphoric acid is added.
- NaOH solution, Be' (16 - 18°), is added to the oil which is held at a temperature of 30 - 35°C, the amount added being such that the acid value is reduced by about three points. The solution is stirred and then separated using Misco-type super-centrifuge with the oil at 40 - 45°C.
- Phosphoric acid (0.1 - 0.3%) is added to the oil at 35 - 45°C, kept and stirred for about an hour. NaOH solution, Be' (20 - 23°), 1.2 - 1.4 times the amount calculated for neutralisation, is added and then stirred. After neutralization, the foots are separated by Misco-type super-centrifuge.
- Warm water (60 - 65°C) equal to oil in volume is stirred into the oil to give the first round of washing, and then decanted.
- The same amount of warm water at a temperature of 75°C is added for the second round of washing.
- Finally, oil is thoroughly washed by stirring in water at a temperature of 85°C to dissolve or coagulate alkali, soaps and other water-soluble substances in the oil. The washing water is then largely separated by settling, while the middle layer is removed by centrifugation.
- Phosphoric acid (0.02 - 0.05%) is added to dehydrated oil at a temperature of 35 - 40°C, stirred for 30 minutes, whereafter activated clay (2%) is added and stirred under vacuum, while the temperature is gradually raised. When the temperature has reached 80°C. more

active clay (2 - 3% is added. While the material is being stirred, the temperature is raised further under vacuum to 120 - 125°C, before being passed through a filter press.

- Bleached oil is de-gassed, its temperature being raised rapidly to 200°C. At 225 - 230°C, superheated steam is blown in at 3 - 4 mm/Hg to deodorize for 1 - 2 hours, the volume of steam being about 5% that of oil.
- The temperature is reduced to 30°C by heat exchanger and cooler, and the oil is then clarified using a filter press.
- De-waxing is done in a cooling tank at temperatures of 0 - 3°C over a cooling period of 48 - 72 hours. Crystallized wax is removed.
- Activated carbon (0.05 - 0.1%) and diatomaceous earth (0.5 - 0.1%) are added to the oil after passing through bag filter. Finished oil is obtained after passing through filter press at 10 - 15°C.

Notes:

1. There are minor differences in the refining operation, depending on the quality of crude oil and the desired quality of the finished product.
2. Yield (%) is based on standard figures. This also differs slightly according to the quality of crude oil and operating skills.

(4) Manufacture of salad oil

Equipment for cooling, de-waxing, refining and finished deodorised oil

The deodorized oil is gradually cooled in the cooling tank, over a period of 3 - 4 days at 20 - 25°C, to separate the solid fat. It is then returned to the refrigerator for another 2 - 3 days and kept at 1 - 5°C to complete crystallisation.

(5) Finishing and dewaxing

The oil is passed through a bag filter or wooden filter press in a refrigerator at +5° - +8°C to remove the solid fat completely, the result being a high-grade edible oil or salad oil.

There are salad oil standards depending on the various sorts of oil, the most general being that the oil must not get cloudy for 5 hours at 0°C. Furthermore, the acid value must be below 0.3 and the oil must be light in colour.

(6) Finishing (bag filter)

Finishing is usually done using the filter press method. However, to obtain oil with a very good colour, once it has passed through the bag filter, the oil is stirred in a cooling tank with a mixture of 0.05 - 0.01% activated carbon and 0.5 - 1.0% diatomaceous earth. The activated carbon has a decolourizing effect, and the diatomaceous earth with a precoated surface is an efficient filter medium which effectively removes any pigment that was not decolourized. The final product is a high quality edible oil with a pleasant flavour.

(7) Salad oil

Salad oil with its pleasant flavour and odour, is used for various kinds of salads and cold dishes. It is appetizing and its pale yellow or nearly colourless appearance does not affect the colour peculiar to the prepared food.

Salad oil must not solidify or become cloudy in cold weather. Hence, the crude oil is winterized after it has been degummed, deoxidized, water-washed, decolourised and deodorised. Following this, low-temperature dewaxing is done to obtain highly refined oil. Viscosity must be low; the oil must not be sticky, nor must it change or polymerize when heat-treated.

The main raw materials used for manufacturing salad oil are olive oil, cottonseed oil, corn oil, soybean oil, and rice-bran oil.

(8) <u>Tempura oil</u>

<u>Frying oil, cooking oil</u>

In Japan sesame oil and rapeseed oil are generally used for tempura oil. However, soyb an oil and more recentl rice-bran oil are being more widely used.

Rapeseed, soybean, safflower, sunflower are also blended with rice-bran oil. Domestic rapeseed production has dwindled recently, and most of it is imported from Canada. Sesame oil is considered a luxury.

At present rice-bran oil is one of the most important domestic oils in Japan. 90,000 tons are produced yearly and 55,000 - 60,000 metric tons edible oil per annum are manufactured.

Table 15.

De-acidification refining process using a caustic solution with rate of yield
(normal process)

CRUDE OIL (acid value 40)
100% 1,000 kg

(De-gumming & De-waxing)

De-gummed oil — 94% — 940 kg
Gum matter & wax — 10% — 100 kg

Alkali Neutralization

Neutralized oil — 60% — 564 kg
Alkali foots — 64% — 602 kg

(Hot water washing)

Washed oil — 99.5% — 561 kg
Wasted water, etc.

(Bleaching)

Bleached oil — 95% — 533 kg
Wasted activated bleaching earth

(De-odorizing)

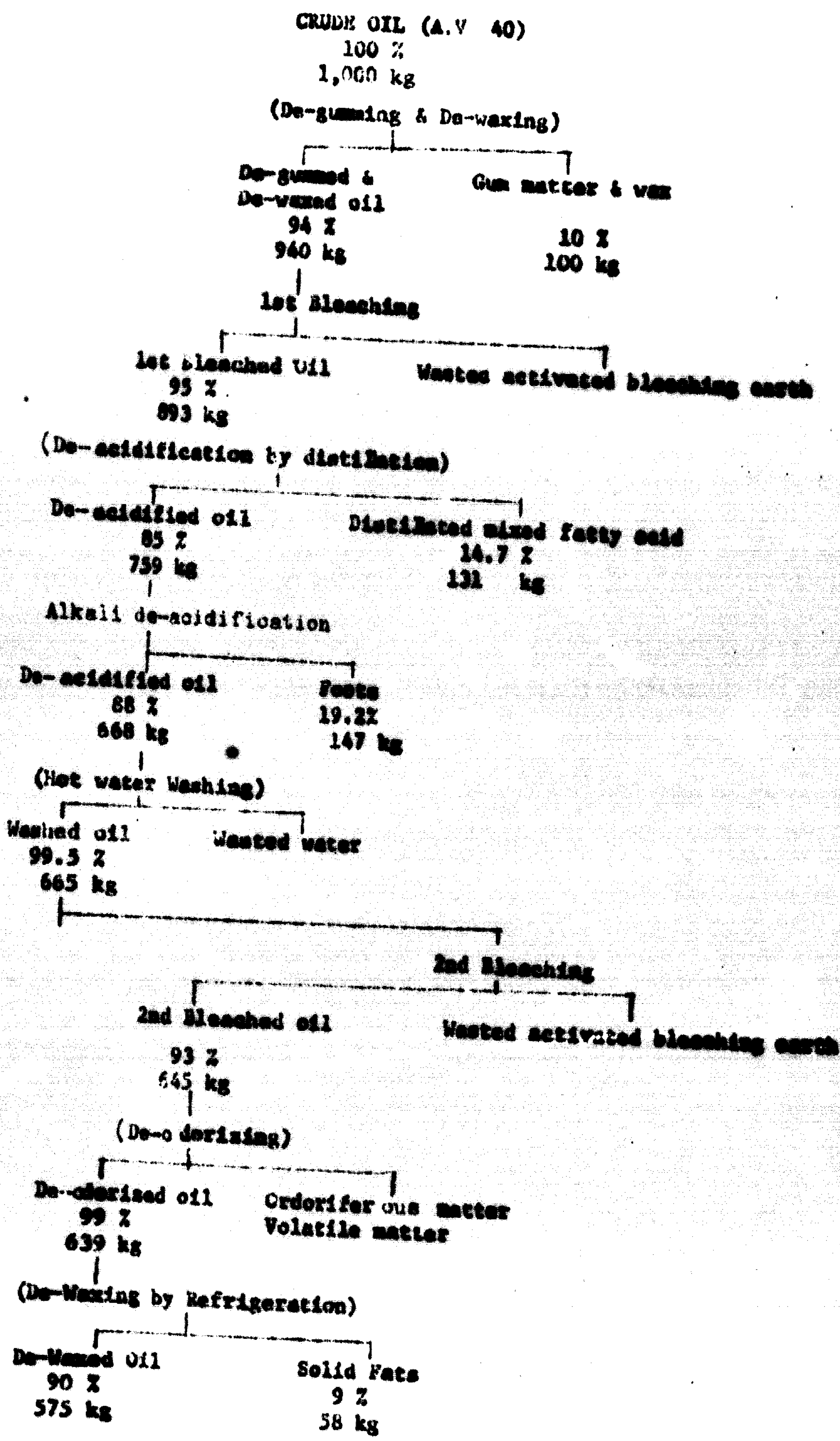
De-odorized oil — 98% — 522 kg
Ordorifer ous matter
Volatile matter

(Wintering)

Finished oil (Wintered oil) — 90% — 470 kg
Fats — 9% — 47 kg

Table 14.

De-acidification refining process using distillation with rate of yield



COST ACCOUNTING WITH DIRECT EXPENSES
(excluding depreciation of equipment)

Table 15.

De-acidification refining process by distillation

I. Crude Oil 1 Ton - 1,000 kg = ₩46,000.00

II. Manufacturing cost ₩ 9,059.00

Details:

1.	Wages & Salaries for the factory	₩1,907.00
2.	Electricity = 70.5 HP	421.00
3.	Fuels	2,649.00
4.	Activated Bleaching earth	3,171.00
5.	H_3PO_4	625.00
6.	NaOH	275.00
7.	NaCl	11.00
		₩9,059.00

III. Products obtained

1.	Edible Oil	575 kg	x	₩110.00	₩63,250.00
2.	Fat	58	x	80.00	4,640.00
3.	Distilated Fatty acid	131	x	40.00	5,240.00
4.	Foots	147	x	8.00	1,176.00
					₩74,306.00

IV. Profit (excluding depreciation)

Cost of the products	₩74,306.00
Cost of the crude oil (-)	46,000.00
Manufacturing cost (-)	9,059.00
P r o f i t	₩19,247.00

De-acidification refining process using caustic solution process

I. Crude Oil 1 Ton - 1,000 kg = ₩46,000.00

II. Manufacturing cost ₩ 5,609.00

Details:

1.	Wages & Salaries for the factory	₩1,350.00
2.	Electricity = 64 HP	240.00
3.	Fuels	1,[illegible]42.00
4.	Activated Bleaching earth	[illegible]34.00
5.	H_3PO_4	375.00
6.	NaOH	395.00
7.	NaCl	55.00
		₩5,609.00

III. Products obtained

1.	Edible Oil	470 kg	x	₩110.00	₩51,[illegible]
2.	Fat	47	x	[illegible]0.00	3,7[illegible]
3.	Foots	602	x	8.00	4,[illegible]
					₩[illegible]

IV. Profit (excluding depreciation)

Cost of the products	₩[illegible]
Cost of the crude oil (-)	46,000.00
Manufacturing cost (-)	5,609.00
P r o f i t	₩[illegible]

(By courtesy of RICE BRAN OIL TECHNICAL RESEARCH INSTITUTE)

Fig. No. 13

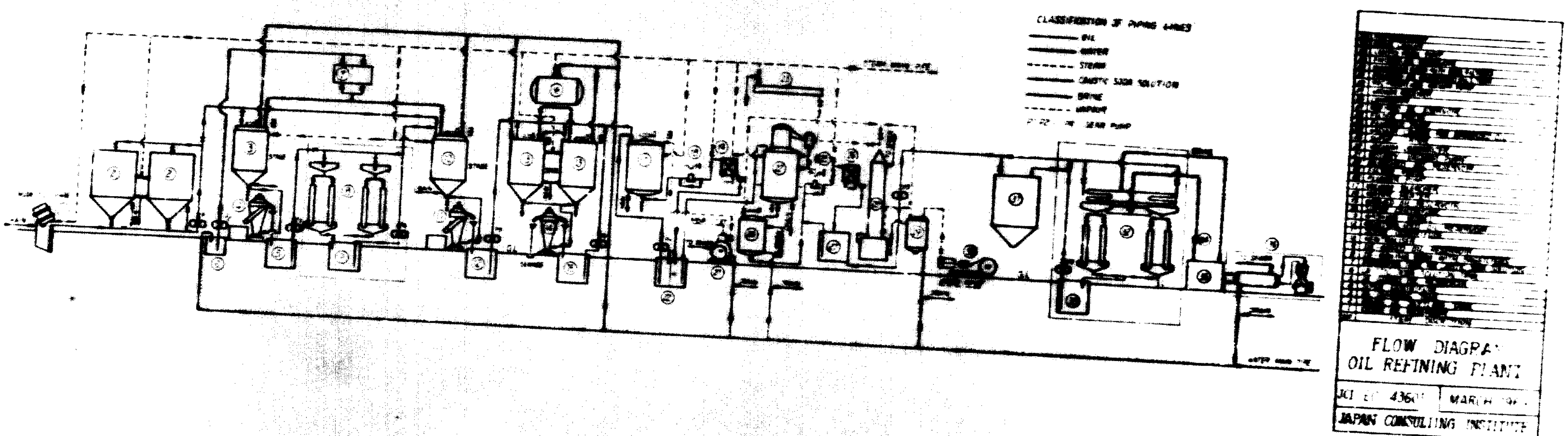
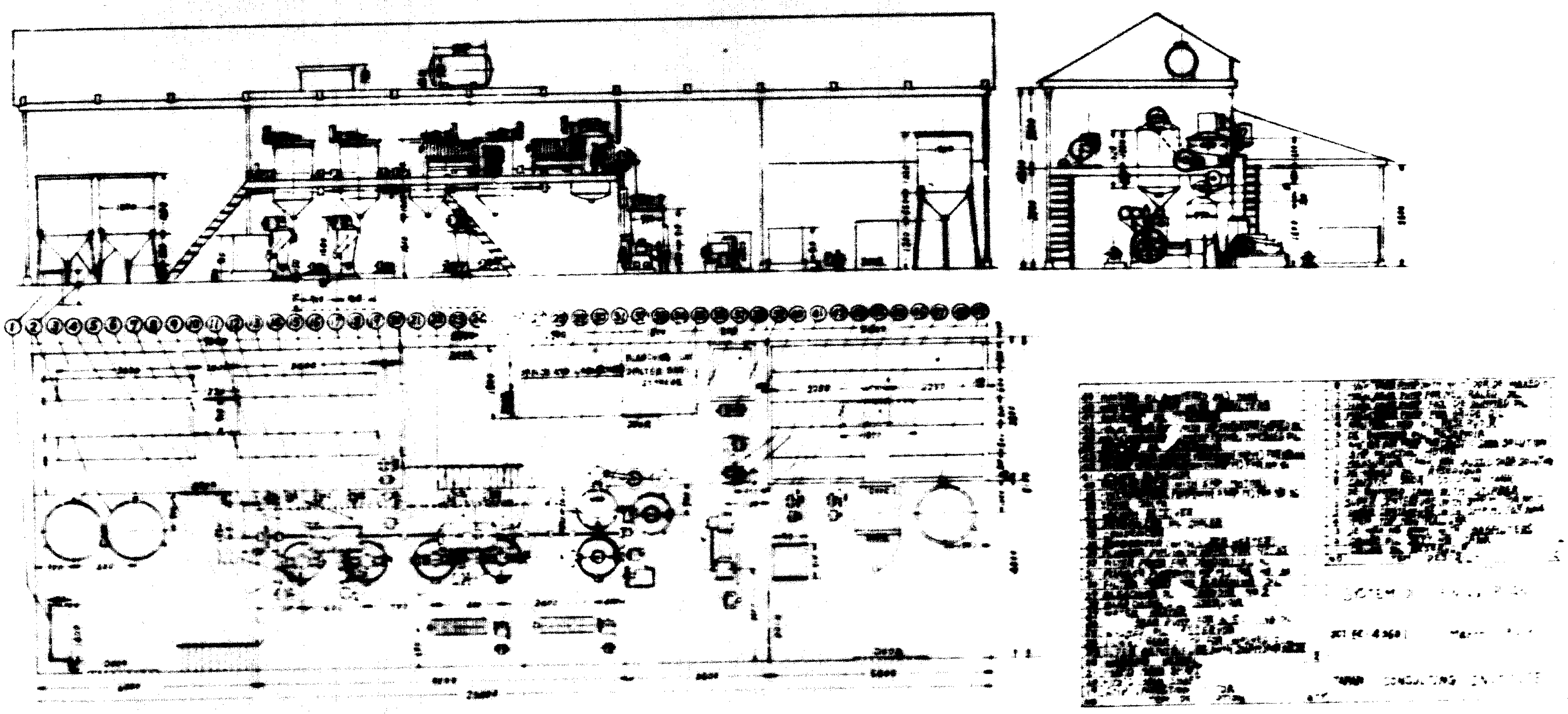

CLASSIFICATION OF PIPING LINES
STEAM
CAUSTIC SODA SOLUTION
FLOW DIAGRA
OIL REFINING PLANT
JAPAN CONSULTING INSTITUTE

Fig. No. 14



Rice-bran oil soap

The use of rice-bran oil as a raw material source for soap dates back some 35 years to the days when rice-bran oil was successfully extracted for the first time in a hydraulic press. As the oil was coloured and contained a large amount of free fatty acids and a variety of impurities, it was difficult to refine and it was tested with a view to making soap. The impurities were removed by means of pretreatment and degumming (H_2SO_4 washing or Zn + H_2SO_4 reduction method) and coconut oil, tallow and other oils were added to prepare semi-boiled or fully boiled soap.

As soap-making techniques improved, rice-bran oil was used as a raw material for washing and toilet soap. The pretreated crude oil was subjected to the Twitchell saponification process, separating the glycerine and fatty acids which were used to produce soaps in conjunction with other oils.

The fat-splitting of rice-bran crude oil is now carried out by the autoclave lime-saponification method as opposed to the Twitchell method which permitted easy saponification and was cheap to install.

Rice-bran oil has a fatty acid structure consisting mainly of oleic acid (35 to 45%), linoleic acid (30 to 40%) and unsaturated fatty acids so that soap made from the rice-bran oil is distinguished by its solubility in cold water and its extensive use as washing soap.

With the growing preference for washing powder, rice-oil soap proved to have the necessary features, and consumption increased. At the peak of the demand for soap powder rice-bran oil was short in supply as its high acid-value was an essential component of soap powder.

Rice-bran oil is also generally favoured as raw material for soap because it is cheap; normally two-thirds and sometimes one-half of that of other soap materials such as coconut oil, tallow and other vegetable oils.

While chemical detergents are predominantly used today, soap powder is still accepted as a useful cleanser and is also used as an important ingredient in detergents.

With growing awareness of environmental hazards use of purely vegetable soap is being contemplated to prevent chemical pollution of metropolitan water supplies. A county in New York, USA, recently prohibited the sale of the detergents, and as this trend develops there will be increasing opportunities for the use of soap powder. Soap powder production will increase and with it the demand for rice-bran oil.

The rice-bran oil industry has been, or is being, mostly developed in tropical and subtropical countries where living standards and the soap utilisation factor are low. Thus, rice-bran plants in these areas should also produce cheap soap powder to help improve local sanitary conditions.

CHAPTER 5. RICE-BRAN PROTEIN MEAL FOR FEED AND FOOD PURPOSES

De-oiled bran has more uses than raw bran.

A. General comments

In Japan about 90% out of the total de-oiled bran produced is used as an animal feed additive or fertilizer. Thus, it is necessary to emphasise the effective utilization of rice-bran for various purposes among the South-East Asian countries, such as Burma, Indonesia, Malaysia, Nepal, the People's Republic of China, the Philippines, Thailand and Vietnam, where the rice-bran oil industry will thrive in the near future.

B. De-oiled bran as cattle meal

It is widely known that de-oiled bran is a more suitable feed for cattle than raw bran. It provides a good source of nutrients for the cattle. The following analysis made at the Ministry of Agriculture and Forestry, Livestock Hygiene Experimental Station and at their various local stations indicates this:

Table 16.

Comparative component analysis
raw bran and de-oiled bran

Components	Raw Bran	De-oiled Bran (pressed)	De-oiled Bran (extracted)
Water	12.59%	9.39%	12.28%
Crude protein	13.31%	16.07%	17.31%
Crude fat	21.21%	11.21%	1.32%
Carbohydrate	34.44%	41.13%	45.49%
Ash	9.40%	11.41%	12.09%
Fibre	9.05%	10.79%	11.59%

In the analysis, raw-bran obtained after milling brown rice was 8% of the total amount. De-oiled bran produced, using the pressing method, contains 11.21% of the residual oil content while a very small amount of only 1.0-1.5% was left in de-oiled bran obtained using the solvent extraction method.

As already mentioned, de-oiled bran is much superior to raw bran as regards preservation: a very important feature whether the feed is to be given alone or mixed with other feed. It includes more protein than raw bran, less starch and is highly digestible.

C. De-oiled bran as fertilizer

Not only do the fat and wax content have no value as fertilising agents, but they are also harmful to the fine roots of the plants. The bran's manurial factor is increased by the removal of both.

The manurial factors in raw bran and de-oiled bran are compared below.

Table 17. Comparison of Manurial Factors in Raw Bran and De-oiled bran

Components	Raw Bran	De-oiled Bran
Nitrogen	1.56	2.6
Phosphoric acid	2.6	5.0
Potassium	0.8	1.8

(N.B. The data issued by Feed Division, Livestock Dept., Ministry of Agriculture and Forestry)

Note: Above samples are not identical with previous table.

From the above, the superiority of de-oiled bran as a fertiliser is apparent. No other organic fertilizer incorporates all three effective factors, although some of them contain large amounts of one or two ingredients. It is generally acknowledged that de-oiled bran, which has a particularly high phosphoric acid content, increases fruit, flower, tobacco production etc., as well as imparting a good flavour.

D. De-oiled bran for seed beds

De-oiled bran can be used without difficulty for sweet potatoes, seedlings and in nursery gardens. However, it requires more water than raw bran, but on account of its lower oil content it is a recommended nutritive.

E. De-oiled bran for medical use

De-oiled bran has many medical applications and is established as a more efficient material than raw bran for producing mould and yeast. Its rice germ is available as vitamins or a base for medicines.

The study of vitamins was initiated by a Japanese scientist, Dr. U. Susuki, who was the first to discover vitamin B1, naming it Oryzanine. Vitamin B1 is indispensable for curing beriberi, a deficiency disease common in the East, and is of importance to nutrition. Thus, bran which contains the valuable nutrients like vitamin complexes (vitamin B1-B6 etc.), amino-acids, phosphoric acid compounds, inositol and others, cannot be neglected in the field of medicine and dietetics.

F. De-oiled bran as food

Raw bran flour should not be used in food on account of the harmful free fatty acid content. De-oiled bran is a better material for biscuits and other kinds of cakes. As de-oiled bran imparts a sweet taste and increases the nutritive value, it should be used more in well balanced national foods. Furthermore, koji malt obtained from de-oiled bran is suitable for the manufacture of miso (bean paste) and shoyu (soy sauce) as it has a large protein, enzyme, amilase content, etc.

(N.B. - De-oiled bran, a yellow powdery substance with a sweet taste and a very attractive flavour).

Protein content

The protein content and other rice-bran components are listed below.

Table 18

	Moisture	Crude protein	Crude fat	Nitrogen-free extract	Crude cellulose	Crude ash
Rice bran	12.7%	15.1%	20.0%	34.6%	9.3%	8.3%
Meal	11.7%	18.2%	2.2%	47.84%	8.3%	11.8%

Ash components:

Potash	15.7%
Soda	0.9%
Lime	0.9%
Magnesium	14.4%
Phosphoric acid	42.4%
Sulphuric acid	0.1%
Silicic acid	15.8%
Alumina	3.6%
Iron oxide	0.6%
Total ash	94.4%

Note: The large phosphoric acid content in the ash.

Essential Amino-Acid Content

Table 19.

Vitamin content of rice-bran compared with other cereals
(in 100 gr.)

Feeds / Vitamin	Rice bran	Yellow corn	Milo	Wheat	Barley	Oats
Carotene (unit)	50	120		180	220	1,200
Vitamin A (unit)	2.4	0.5-3			5.0	0.5-1.0
Riboflavin (mg)	0.2	0.11	0.1	0.13	0.15	0.1
Nicotinic acid (mg)	3.0	1.98	3.0	5.7	5.3	1.5
Pantothenic acid (mg)	2.0	0.5	0.9	0.7	0.6	0.9
Urine (mg)	101.0	44.0	45.0	66.0	88.0	93.5
Folic acid (mg)	0.4	0.02	0.02	0.04	0.06	0.02
Pyridoxine (mg)	4.0	0.5	0.6	0.4	0.2	0.15
Vitamin B12 (r)					Trace	
Thiamine (mg)	2.3	0.4	0.5	0.5	0.6	0.6
Biotin		0.01	0.01	0.01	0.07	0.03

Possible use of rice germ meal as human medicine

A. The principal component of wakamoto tablet:

(1) Culture of aspergillus oryzae mould on rice germs.
This culture produces active digestive enzymes, such as diastase, protease and lipase, which are more active and richer than those found in yeast. These cultures are used in Wakamoto tablets with the intent to promote digestion and increase the appetite.

(2) Culture of eremothecium ashbyii mould on rice germs.
This culture contains much Vitamin B_2 as well as Vitamin B1, B6, B12 and others belonging to the Vitamin B complex, such as nicotinic acid amide, folic acid, pantothenic acid and inositol in their natural state. These cultures are compounded in wakamoto tablets as a nutritive source and activate the metabolic energy and intensify intestinal resistance to disease.

(3) Culture of active lactobacillus.
Ever since Dr. Mechinikhov expounded his famous theory that lactobacilli increase in the intestines promoted health and contributed to longevity, it has been studied by many scientists in various countries and has become accepted by medical circles. However, as lactobacilli in a dehydrated state are comparatively weak, technical precautions are required during their preparation. This difficulty has now been successfully overcome by cultivating active lactobacilli on rice germs and drying them to powdered form.
Active lactobacilli included in wakamoto tablets regulate the intestinal condition.

(4) Drv yeast.
Dry yeast is mentioned in the pharmacopoeia of Japan and USA. It is mainly composed of protein, fats and glycogen with a small amount of nutrients, i.e., Vitamin B complex, and enzymes. These ingredients are nutritionally useful, stimulating the appetite and regulating bowel movement.
As wakamoto is a compound preparation composed of micro-organisms, enzymes and vitamins, it improves digestive activity and regulates the intestines.

B. Composition of wakamoto

Table 20. In 100 gr.

Culture of aspergillus N.K.	50.00 gr.
Culture of eremothecium ashbyii	6.25 gr.
Dried yeast	35.00 gr.
Inactive substances	1.25 gr.

Table 21. (Analysis)

The following are contained in one gram (4 tablets) of the product.

Vitamins

Vitamin B1 .... 250 r .... Nicotinamide 300 r

Vitamin B2 .... 250 r

Other components of V.t.B.

Active digestive enzymes

Diastase; protease; lipase; etc.

Active lactobacilli

Streptococcus faecalis ...... more than 7.5 million.

Mineral , protein and amino acids

Protein .... more than 30 per cent, including over 16 amino acids.

The development of the rice-bran oil industry in South-East Asia is closely related with rice milling and processing. Hence, there is a particular need to modernize rice mills except in those countries where husking and whitening are separate processes and pure bran is produced.

It is recommended that a rice-bran oil industry be established whenever the rice milling industry is modernized. Every effort should be made to promote the rice-bran oil industry as it contributes greatly to self-sufficiency in the food, feed and fertilizer sectors, and is a potential foreign exchange saver and/or earner.

The author wishes to express his thanks to those people who so kindly co-operated with him and looks forward to their further assistance in the development of the rice-bran oil industry.

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