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STABILIZATION OF RICE BRAN[1/]

by

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I. Introduction

The industrial and nutritive potential of rice bran is very high. This byproduct could provide 5 million tons of proteins of high quality as well as 5 million tons of edible oil yearly. Proper utilization of rice bran could contribute to palliate the scarcity of proteins and fats in developing countries of rice growing areas. In addition to the revaluation of rice itself, utilization of rice bran could give birth to new industries of which the rice sectors are necessitating for development.

Today however, the utilization of rice bran is dramatically minimized by its fast deterioration. Integration of rice mill and oil extraction plant is an ideal solution. Nevertheless, the atomisation of the rice industry, common to all countries, makes the production rate of their mills insufficient to supply the extraction plant. The rational modernisation of this infrastructure requires great investments and long time.

At present, for rice bran supply to oil extraction plants it is necessary to gather the production of several mills, transport and store it. So this requires the previous stabilization of the byproduct just at the mill site. The same solution is required for utilization of bran in food manufacture.

Several countries have developed methods of rice bran stabilization. However, the existing processes cause important losses of nutritive value, by destroying vitamins and amino acids, and/or do not inactivate total and irreversibly all the enzymes responsible for bran deterioration. In any case, there is a lack of adequate industrial machinery. That is why the processes developed up to now have not been successful in their practical application.

1. Fundamentals of the rice bran stabilization technology

The basic principles governing rice bran stabilization have been recently established and will be most helpful in evaluating appropriately processes and equipment.

Natural lipases are a major cause of deterioration of bran after milling. They and the substrate come together by milling and oil deterioration starts. Under certain conditions, other enzymes also naturally present in the rice grain can deteriorate bran oil. Peroxidases cause oxidative spoilage of bran constituents at low moisture content. Some enzymes, like peroxidase, can regenerate their activity after total deactivation if special provisions are not made. Other enzymes, like lipases, which activities have been suppressed by combining partial inactivation and dehydration, are reactivated when moisture contents increases.

Commercial bran has a high microbial population, frequently exceeding four millions microorganisms per gram. Molds - including heat-resistant spores - able to produce active lipases and mycotoxins are always present.

Insects, whether adults, larvae or eggs, are usual contaminants of commercial rice bran.

In order to process rice bran into a food grade product of good keeping quality and high industrial value, all above mentioned causes of spoilage must be arrested. Enzyme inactivation must not be only complete but irrevessible. And inactivation must be carried out as soon as possible after milling, preferably at the mill site. Heat resistance of rice bran enzymes depends upon temperature and time of treatment as well as on moisture content, the latter being a critical parameter. The higher the moisture content the lower the heat resistance. Realization of this fact allows to perform effective stabilization under the mildest conditions possible, keeping processing cost low and retention of nutrients and food grade properties of bran high.

Effectiveness of stabilization can be assessed easily. Measurement of residual peroxidase activity has proved to be a reliable and practical method for it. Peroxidase is the most heat resistant enzyme in bran. Its destruction assures inactivation of lipases and other enzymes. There is no need for storage tests to assess the effectiveness of stabilization. Available quick methods for peroxidase evaluation allow in-line quality control of the stabilization process, which is of outstanding importance to assure successful industrial practice.

Well stabilized rice bran has excellent keeping quality provided adequate protection measures from microbial, insect and other pests are taken. Like wheat flour and many other food products, stabilized rice bran demands appropriate storage technology.

2. Processes for rice bran stabilization.

Most of the processes developed involve dry or moist heat treatment. Use of chemicals or γ-irradiation, as well as storage under low-temperature and/or inert atmospheres have also been suggested although they have never been accepted as reliable, practical procedures.

It has been claimed that dry heat treatment produces rice bran of satisfactory keeping quality. However, several of the following drawbacks are common to all these methods : 1) Severe processing conditions; although they damage the bran, quality losses have been neglected. 2) Substantial moisture removal with high calorie-consumption. 3) Complete and irreversible inactivation of enzymes is not achieved. 4) Low moisture content of bran during storage is a must.

Moist heat processes generally involve steaming bran for 3-30 minutes, drying to 3-12% moisture content and cooling. Cooking and extrusion under high pressure is another alternative. It is generally recognized that moist heat is more effective than dry heat. Notwithstanding, out of the many processes using steam, few have achieved satisfactory results. For proper stabilization, every discrete particle of bran must have a determined moisture content according to processing temperature and time. Adequate, uniform moistening and treatment of every discrete particle, whichever the lot size of bran is - grams or tons -, is not easily achieved. Bran agglomerates with moistened surface but dry core are usually formed. When properly performed, steaming bran for 3-5 minutes at 100°C, followed by drying up to initial moisture content and cooling accomplished satisfactory results.

3. Rice bran stabilization R&D at IATA

In the "Instituto de Agroquímica y Tecnología de Alimentos" (IATA) a process for the stabilization of rice bran, as well as the machinery necessary for it have been developed. The process attains:

1) Complete and irreversible inactivation of enzymes
2) Minimization of microflora
3) Destruction of insects
4) Improvement in the product digestibility
5) Prolonged safe storage of rice bran

The process consists of a hydrothermic treatment of bran through which to byproduct is treated with steam, dried and subsequently cooled.

To optimize this process, it has been necessary to make a previous study of its basic aspects such as its effects on the enzymatic activities, nutrients, and physical and chemical characteristics of bran as related to moisture content, pH, microbial population, rice milling diagram, previous history of the rice stock, etc.

After having studied the process, the Institute has concentrated its efforts on the development of the necessary equipment for its industrial application. These efforts have led to the development of two disactivating machines, explained later on. Such machines, intended to operate in mills lacking steam , have been designed as autonomous units provided with their own steam source.

4. Stabilising units

They have been named A and B. The A unit disactivates the rice bran keeping it as a powder while the unit B processes bran into pellets. In both units the process begins by direct heating and wetting the bran with steam on a fluidised bed. In unit A the inactivated bran is unloaded into a flash dryer to get a final dry and cool powdered product. The complete process takes about 3 minutes. In unit B the hot and wet bran is extruded into pellets, dried and cooled.

At present, the A unit with a capacity of 100 kg/h and 450 kg/h is being manufactured and commercialized. The B disactivator is in an advanced pilot stage.

The most important characteristics of the A unit are summarised below :

(a) It is continuous

(b) It is easy and simple to operate. Trained personnel is not required

(c) Its production rate can be varied. The A - 450 unit can work satisfactorily within the 100 - 450 kg/h range, and the B - 100 unit within the 50 - 100 kg/h range

(d) Man labour is low. Practically, only a watchman is required.

(e) It is made of a resistent material and its simple mechanism minimizes risk of breakdown or failure. Repairs can be easily made even in rural areas. Spare parts are easily acquired or made

(f) The equipment is compact and does not require of any special work to be installed

(g) The unit is light and takes little room

5. Sources of energy

To fill the lack of steam or other caloric sources frequently occurring in rice mills, it has been developed a steam and hot air generator adapted to the special needs of the EIVD units. These needs are: low investment and operation costs, and simple performance and maintenance. Taking this into account, a heat source has been developed consisting of a commercial air heater provided with a device to generate steam.

Both generators to be used can be of two kinds: by indirect heating or by mixing air with combustion gases. In both cases, the steam generator device is easy to be installed and not expensive. The equipment of indirect heating type using gas-oil, petroleum or fuel-oil, is ready to be commercialized; another unit using rice husk is under study. The equipment mixing air with combustion gases is being experimented on an industrial scale; results up to now are entirely satisfactory.

6. Characteristics of stabilized rice bran.

6.1. Physical characteristics.

Equilibrium moisture of powdered or pelletized rice bran stabilized as stated above is 10 % (room temperature 15-30 ºC and relative humidity 50-85 %). Such a level is entirely satisfactory to prevent both hydrolysis and rancidification of fats. Higher or lower levels would be less adequate.

Bulk density of stabilized bran is greater than that of raw untreated bran (Table II); storing and transport of powdered stabilized bran and pelletized stabilized bran requires, respectively 0'7 and 1'1 m3 per ton less than in case of the untreated product.

Table II. Bulk density of raw and stabilized rice bran (a)

Raw rice bran		0'32
Stabilized rice bran		
A	unit (powder)	0'41
B	unit (pellets)	0'50

(a) gr/cc
(b) Pellets 1 cm long and 6 mm diameter

With regard to particle size distribution, simultaneous stabilization and pelletization mean some advantages, not only in volume saving but also in handling. The pellets are as well more adequate for continuous oil extraction. On the other hand stabilized bran powder also contains less proportion of fine particles than the raw material (Table III).

Table III. Size particle distribution in raw and stabilized rice bran

Size (μ)	Raw rice bran (%)	Stabilized rice bran (%)
>500	3'34	5'25
500 - 250	30'29	41'.4
250 - 125	40'03	38'21
<125	26'33	15'09

Stabilized bran is darker than untreated bran; however, the differences are not important (Table IV).

Table IV.- Effects of stabilisation on the colour[a] of rice bran

	L	a	b
Raw rice bran	62'0	0'2	15'6
Stabilized rice bran			
A unit (powder)	53'2	0'7	16'6
B unit (pellets)(b)	57'3	1'3	16'8

(a) Hunter colour: white standard (L = 93'6, a =-1'0, b = 2'3)
L, luminosity; a, red components; b, yellow components.

(b) Sample ground to pass 20 - mesh sieve.

6.2. Insects and microorganism

The process of stabilization destroys the microorganisms and insects-whichever the vegetative from in which they are found (Table V).

Table V. Effects of stabilization on the microflora of rice bran.

	Total count microorganisms/g	Molds/gr
Raw rice bran	3.770.000	110.000
Stabilized rice bran		
A unit (powder)	2.200	135
B unit (pellets)	180	0

The destruction of molds spora is specially important in order to prevent their growth and lipase production.

6.3. Chemical composition

6.3-a. Average chemical composition. The average chemical composition of stabilized rice bran is given in table VI.

Table VI.- Average chemical composition[a] of stabilized rice bran.

Protein[b]	15'34 - 17'09
Fat	15'03 - 20'66
Ash	8'73 - 10'45
Fiber	6'76 - 10'20
N-free extract	44'16 - 48'76

(a) %, d.b.
(b) N x 6'25

Stabilization does not change original composition

6.3-b. Enzymes. Treatment of rice bran desactivates complete and irreversibly the lipase and other enzymes responsible for fat deterioration.

Desactivation is attained even when special conditions originating anormally high enzymatic activities are found. For instance, when harvesting in raining season prevents proper drying.

6.3-c. Nutritive value. Thiamine contents of untreated and treated bran are 39'9 and 37'0 mgr/kg. Overall retention of thiamine is therefore very high-not less than 95 %.

6.3- d. Natural toxicants in bran. Trypsin inhibitors and hemmaglotinins are inactivated.

Such satisfactory results are to be expected due to processing conditions: high temperature short times

7. Storage life.

Stabilized rice bran can be stored for months without deterioration (Fig. 3 and 4). Enzymatic activities are not regenerated.

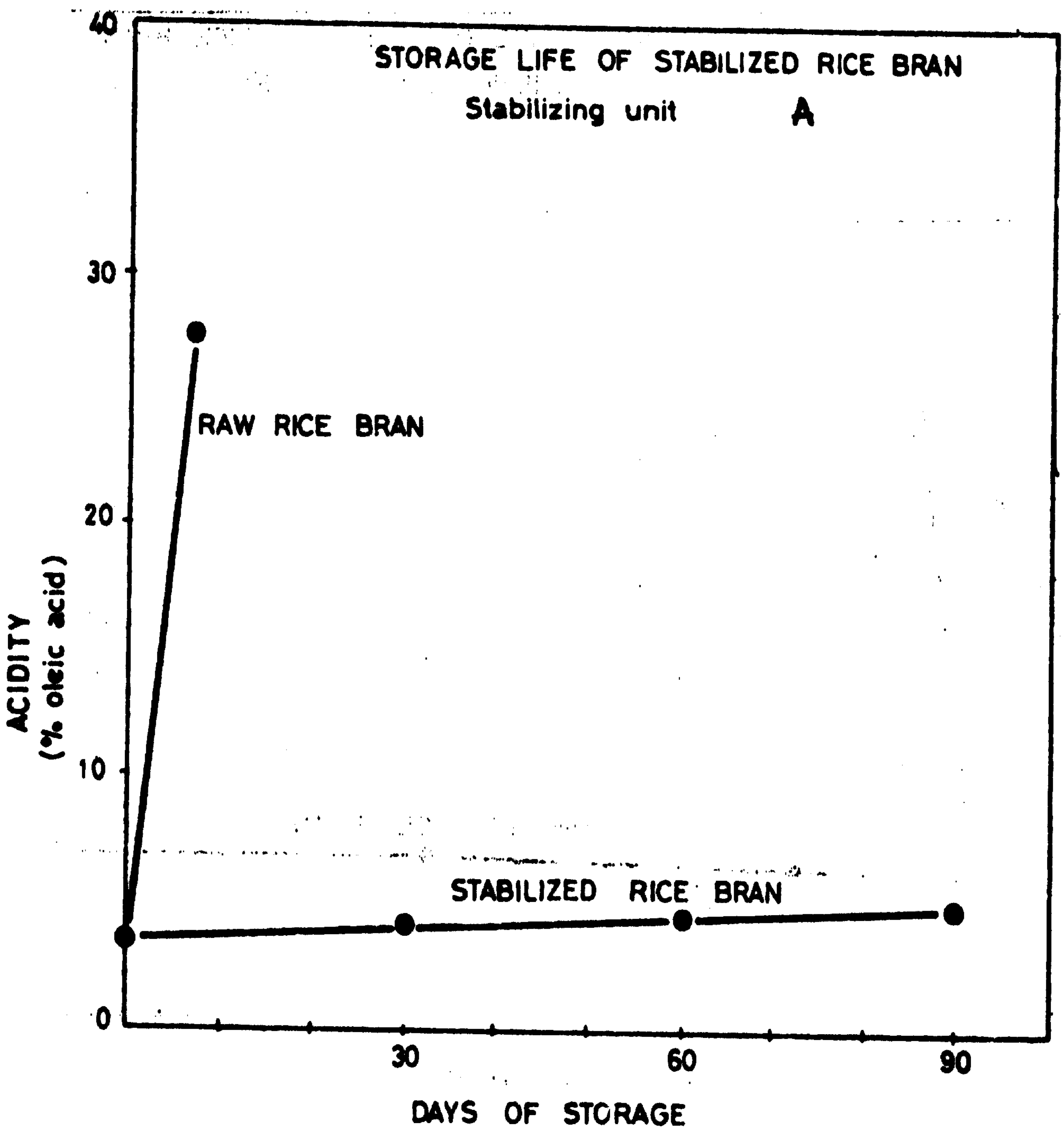


Fig.3.– CHANGES IN ACIDITY DURING STORAGE OF RICE BRAN (Rice bran stored under room conditions in plastic bags, 1 Kg. capacity)

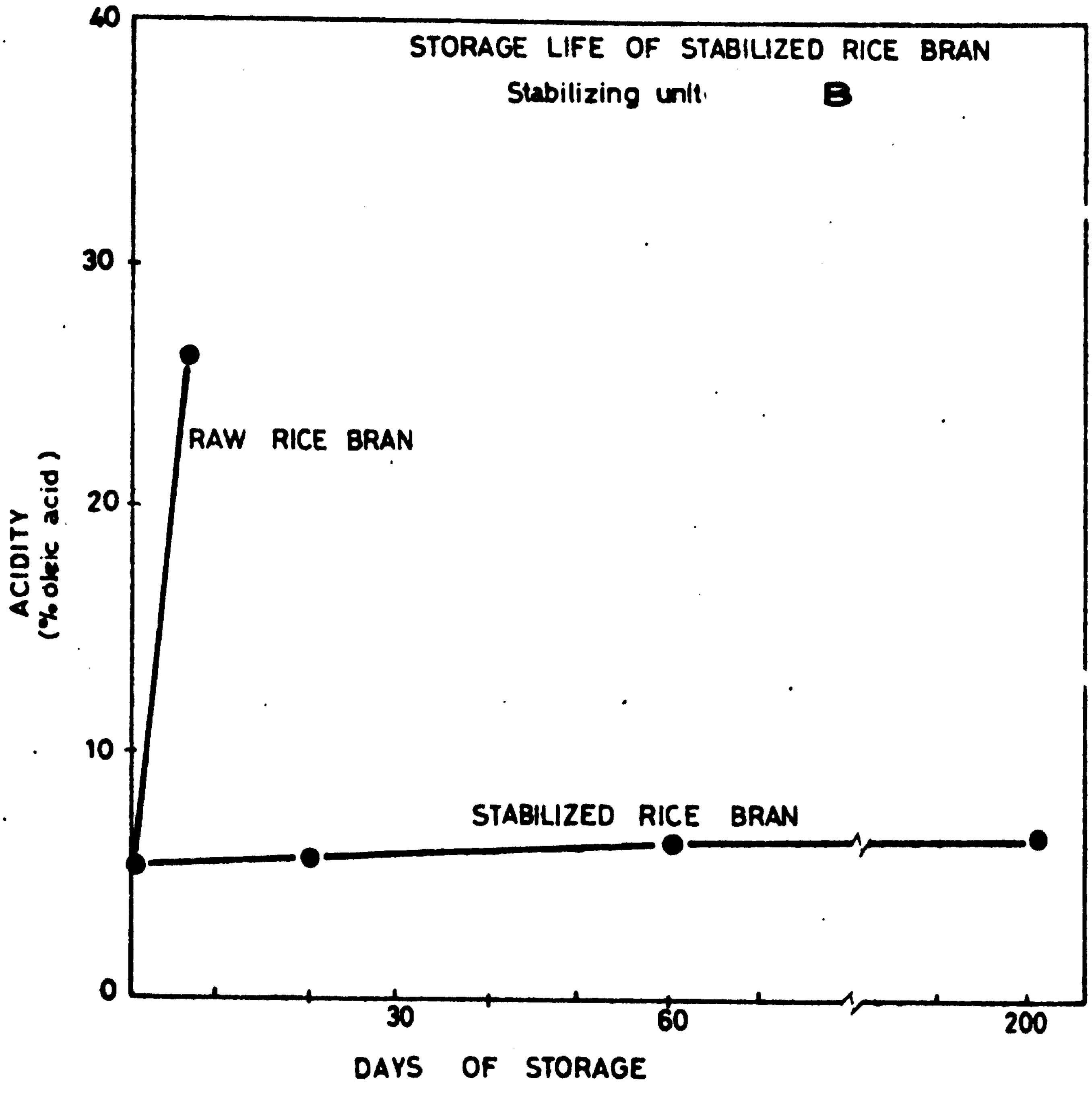


Fig. 4.— CHANGES IN ACIDITY DURING STORAGE OF RICE BRAN
(Rice bran stored under room conditions in plastic bags, 1 Kg. capacity)

<u>Industrial utilization</u> : Oil extraction

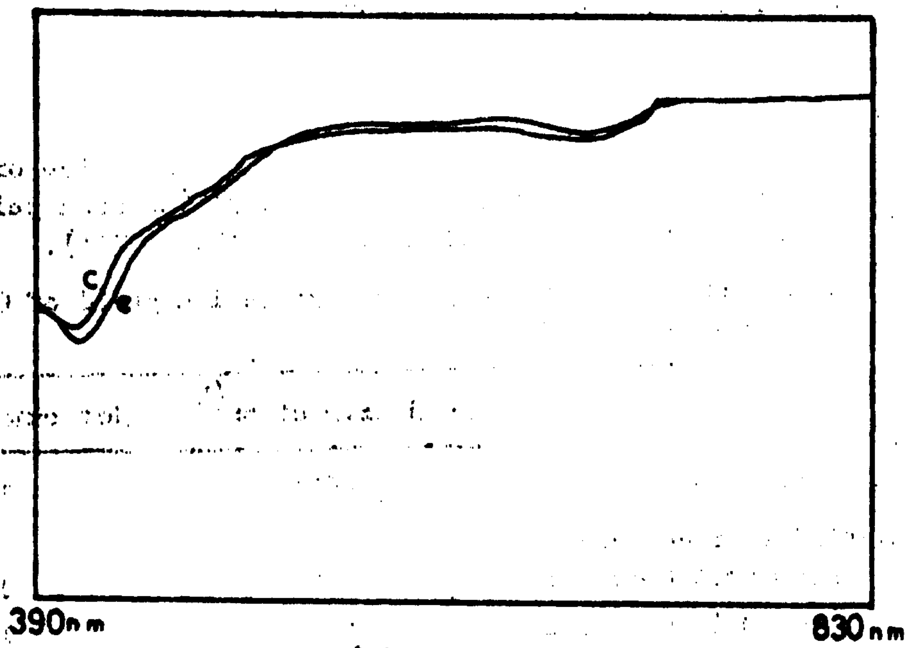
Oil extraction yield from stabilized powdered rice bran (A unit) is similar to that from raw rice bran. Yields from pelletized bran (B unit) appear to be slightly lower (Table VII).

Table VII. Effects of stabilization on extraction yield of Oil from rice bran (a)

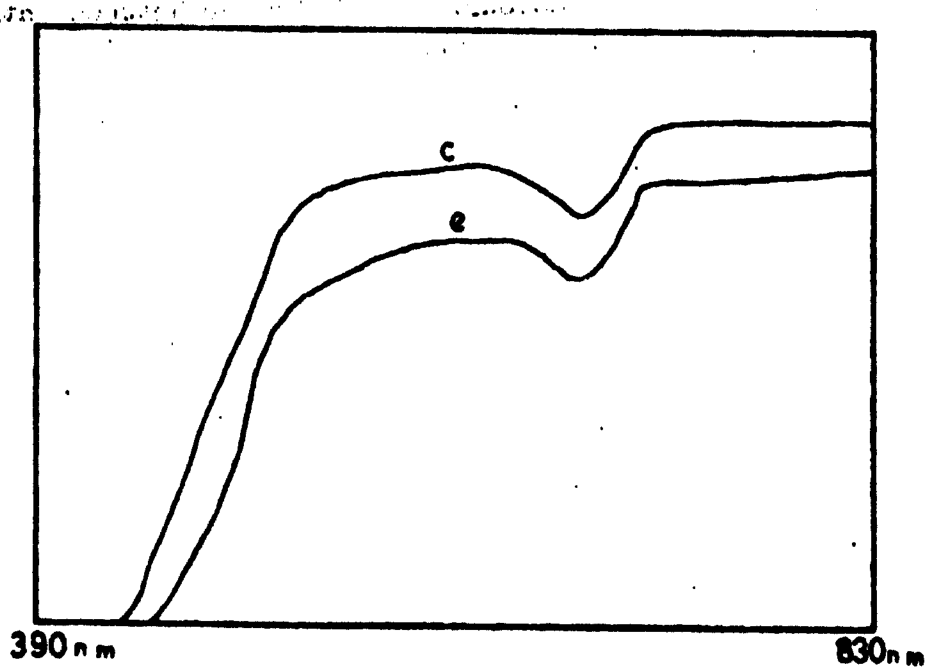
	Cold extraction (b)	Hot extraction (c)
Raw rice bran	16·3	18·3
Stabilized rice bran		
EIVD unit (powder)	16·4	18·4
EECS unit (pellets)	15·7	17·6

(a) Hexane-extracted oil, % d.b.
(b) Six hours extraction; rice bran: hexane, 1:5 (w:v)
(c) Four hours extraction, Soxhlet apparatus

With regard to oil colour, the difference between untreated and stabilized bran are small (Fig. 5).



a) Cold extraction



b) Hot extraction

Fig.5._ ABSORBANCE CURVES OF HEXANE EXTRACTED OILS OF RAW AND STABILIZED RICE BRAN. (c = raw bran; e = stabilized bran)

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