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Interregional Seminar on the
Industrial Processing of Rice

SUMMARY

REVIEW OF RICE PROCESSING TECHNIQUES [1]

by

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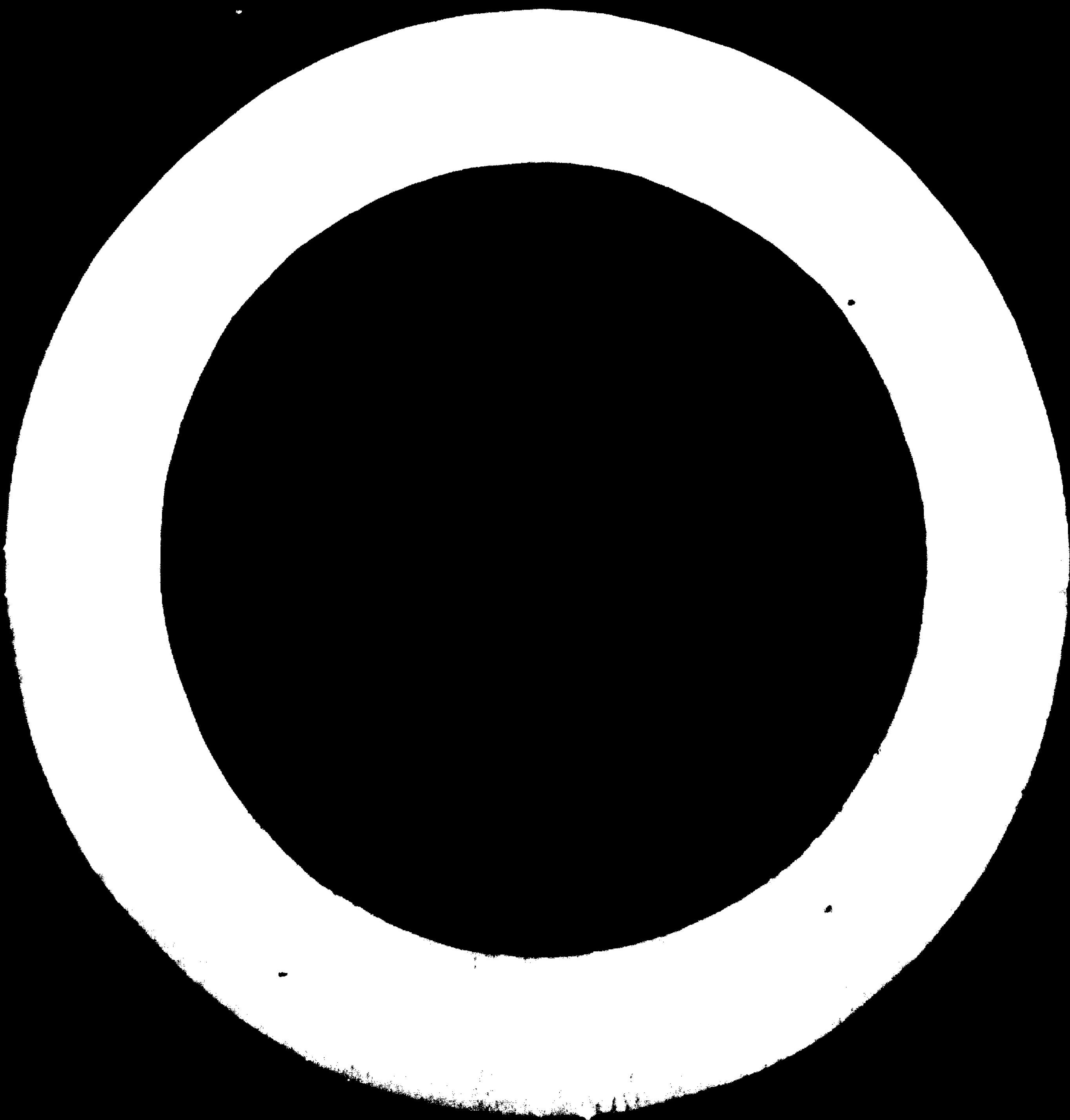

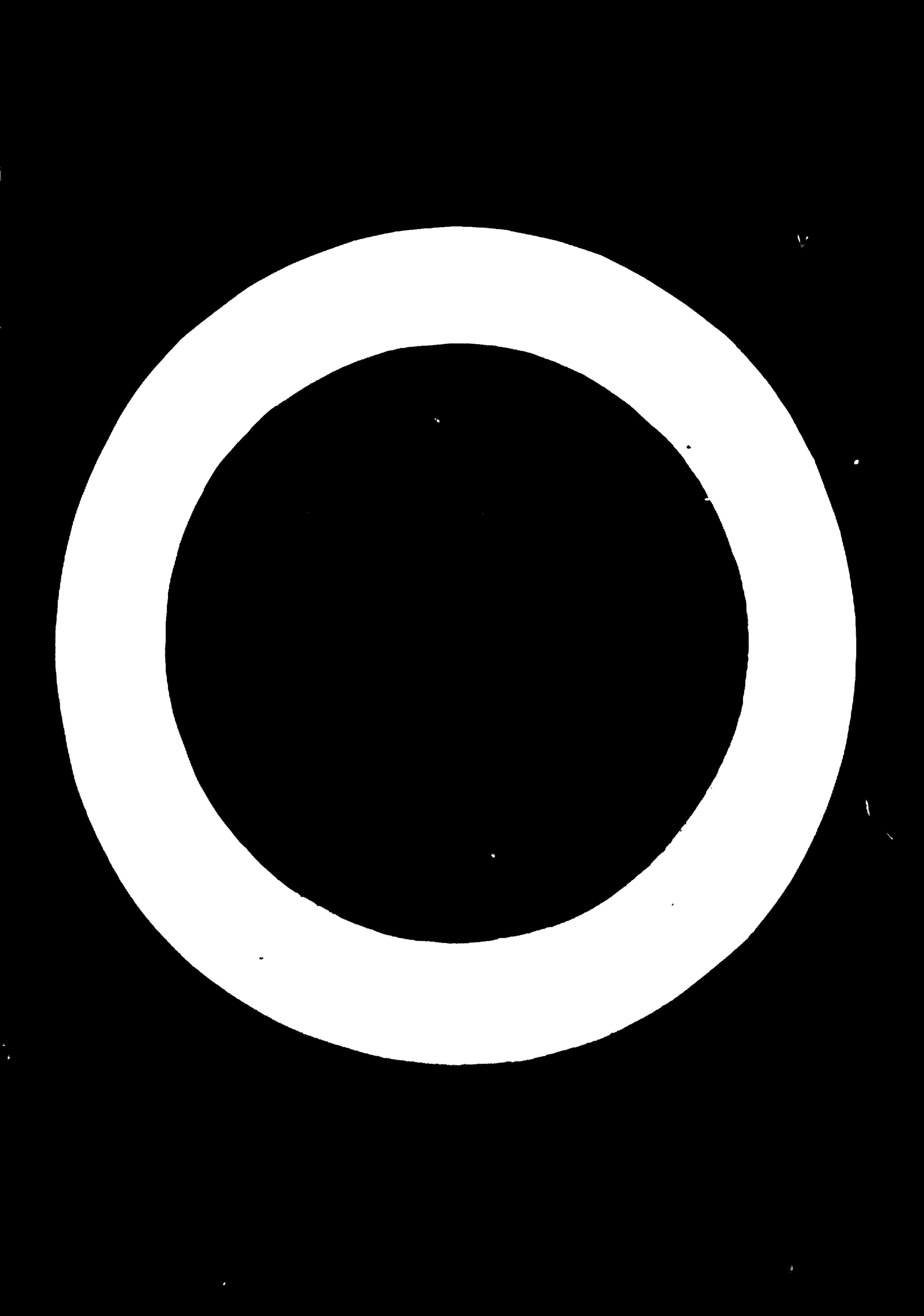

INTRODUCTION

1. Traditionally paddy in Asia has been sun dried, stored in inadequate facilities, and milled with the most obsolete equipment. These traditional methods and equipment incur substantial losses. With modern technology and equipment, we are learning how to reduce the losses and provide more and better rice to the consumer.

2. Harvesting and Threshing: The traditional process involves sun drying of the paddy in the field, harvesting by hand, and threshing by hand and bullocks. Through this process, substantial quantity of paddy is lost in the field and through the handling techniques. Several authors have reported on studies of harvesting methods. These authors report that early harvest of paddy, immediately after maturity, produces a higher field yield, from 14 to 22% above late harvest, and release the field 1 to 2 weeks earlier for other crops. Experience has shown that paddy can be harvested and threshed at high moisture levels as easily as low moisture levels. Improved harvesting techniques also produce a cleaner paddy, which reduces future processing cost.

3. Drying: Traditionally, paddy in most of Asia is sun dried, either while the paddy is standing in the field or on drying yards after threshing. The sun drying causes the paddy grain to "sun check", which causes breakage during milling, resulting in lower head and total yields. Substantial losses to rodents and birds also occur. To overcome these losses, mechanical drying is being used. One study reported the head yield of IR-8 when mechanically dried, increased by 17.2% and the total yield increased by 0.7% over sun dried paddy.

4. A large number of LSU dryers are now being used in India. These dryers, complete with scalper cleaners, conveying systems, tempering and storage bins provide a quick, economical means of mechanical drying paddy. Drying cost with these drying systems range from $0.77 to $2.13 per ton of paddy, depending on the plant operation.

5. <u>Storage</u>: The traditional method of storage, involved storing the paddy in gunny bags, and the use of labor to move the gunnies. This system of storage has losses of 5 to 10%. The new storage structures are designed to maintain grain quality and quantity during the storage period. To maintain quality, the paddy going into storage must be of the highest quality, clean, free of insects, and dry. Two types of improved storage facilities are being used. One is improved godowns. These godowns are constructed with the floor above ground, moisture proof and rodent proof. The paddy is stored in gunny bags, and requires large labor for loading and unloading.

6. The second type of improved storage is the use of silos with mechanical handling equipment. In these silos, the paddy is stored safely, free from insects and easily aerated or fumigated. Losses are negligible. Building cost of silos in India are approximately that of godowns, $21.00 to 30.00 per ton of storage. The silo operation cost is less than godown operation cost, thus making silo storage the least expensive. In one study storage cost was 29 cents per ton per month for silos, and 35 cents per ton per month for godowns. Storage should not be considered in isolation but along with other problems related to post harvest period.

7. <u>Parboiling</u>: Parboiled rice is preferred by some consumers in Asia. Parboiling also increases the milling outturn of most varieties. A number of traditional methods of parboiling are practiced. They consist of soaking the paddy for 2 - 4 days, then boiling the paddy for a short

period. Different types of soaking tanks and steaming kettles are being used. These processes tend to ferment the paddy and produce a disagreeable color and odor. A new method of parboiling has been introduced in India.

8. The equipment for this method consist of a parboiling tank, holding 3 - 5 tons of paddy. The paddy is soaked in hot water for 3 hours, then steamed in the same tank for 15 minutes. The paddy is then moved to a mechanical dryer, where it is dried to a safe moisture level for storage or milling. A diagram of the tank, flow diagram, and plant layout is shown. This method of parboiling with the equipment appears to be one of the most practical and economical methods of parboiling.

9. Milling: Most of Asia's paddy is milled with hullers. In some areas hand pounding is still practised. The modern rice mill program, in India introduced modern 1, 2 and 4 ton per hour modern rice mills. Each modern rice mill consists of a pre-cleaner, rubber roll sheller, paddy separator, friction or abrasive polishers and rice graders. After studying these mills, with the traditional mills, it was found that modern mills, gave a higher milling outturn with less brokens, and a cleaner rice. This difference in milling outturn and the economic advantages of the modern mills, has led to a rapid expansion of modern rice mills in India.

10. The modern processing plant is a small industry, involving procurement programs, transportation systems, drying, storage, and milling facilities, and marketing programs. To meet the expected results of such an industry; modern equipment, trained operators and technicians and skillful management is required. Planning a modern paddy processing plant should include careful, detail planning of all these items.

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[illegible] OF RICE PROCESSING [illegible] 1/

by

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The Ford Foundation, Islamabad, Pakistan

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CONTENTS

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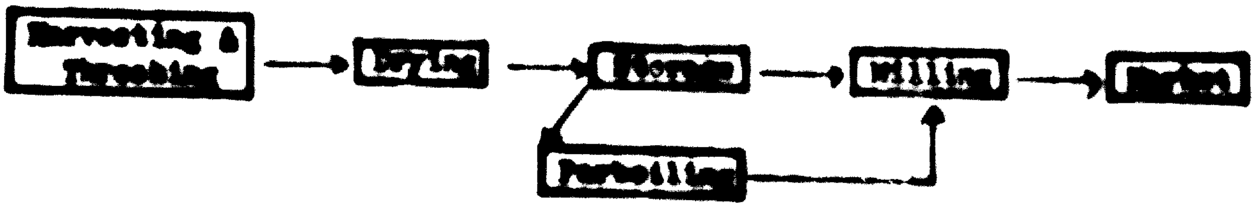
1. Rice Processing may be defined as producing edible rice from field paddy. This involves many different distinct steps, and each has its effect on the final product. A diagram of the complete processes is:



Where:

- Harvesting & Threshing is the operation of removing the paddy and straw from the field and then separating the paddy grain from the straw.
- Drying is the process of reducing the moisture content of the paddy from a relatively high moisture level at maturity to a relatively low level for storage and future processing.
- Storage is the practice of "keeping" the paddy from harvest time till it is milled.
- Parboiling is a process in parts of Asia to "change" the physical and chemical properties of the rice kernel to provide certain benefits.
- Milling is the process of removing the husk and bran layer from the paddy kernel.
- Marketing is the operation of moving the finished rice from the mill to the consumer.

2. Through laboratory experiments, adaptive research and processing experience, we have found how the final product is affected by these different processing steps. The technology, including the methods employed, the equipment used, and the economics of operation will be discussed in detail in this paper.

Harvesting and Threshing

3. Each variety of paddy has its individual properties commonly known as "varietal characteristics". This means that varieties may differ with respect to harvesting, threshing or milling to other varieties when harvested, threshed, dried or milled. Most varieties of paddy reach a uniform state of maturity (95 - 98% of all kernels on the stalks are mature at the same time) at a grain moisture level of 20% to 26%.

4. Paddy moisture content differs as practices vary as to methods and time of harvesting and threshing. In some areas of Asia, paddy is allowed to stand in the field until it sun dries to 15 - 17% before it is harvested. In other areas it is "cut" at 20 - 26% moisture and "stacked" until it is sun dried to a lower moisture level before threshing. Still other areas harvest and thresh paddy at relatively high moisture levels (20 - 26%).

5. Throughout Asia, nearly all paddy is harvested and threshed by hand. The paddy stalk is cut from the stubble and moved to a threshing floor. The paddy is then separated from the stalk by hand beating, trampling by bullocks or a combination of the two. In some areas, different types of simple mechanical threshers are being used to remove the paddy from the straw. These methods are quite different from the mechanized approach in other parts of the world where paddy is harvested and threshed by combines.

6. Both the harvesting and threshing methods as well as the grain moisture content, affect the quality and yield of paddy. Several authors have reported results of harvesting and drying studies at different moisture levels (1, 2, 3).

7. Bhole, Rao, Bal and Wimberly (3) report on studies involving IR-8 in south India. "IR-8 was studied during Kurvai season (October - November harvest) and the optimum harvest moisture content Fig 1 was found to be between 21 to 24%. The average field yield at optimum harvest moisture level was 6740 kg/ha which was reduced to an average yield of 5550 kg/ha when the crop was harvested at 15% moisture level. The percent difference in field yield between these two harvest moisture levels was 21.6%."

8. During the sun drying process, the over mature paddy began to shatter or fall from the stalk and is lost in the muddy water or soil. Some of the mature paddy is consumed by birds and rodents and some is lost in the cutting and transporting. These losses account for the 21.6% reduction in field yield during the field drying, harvesting, and threshing process. The field losses for varieties other than IR-8 in the same study were: ADT27, 29%; ADT-8, 15.2%; and CO-25, 14%.

9. From these reports and many others, it may be summarised, that paddy harvested at the optimum moisture level, following maturity, produces more yield per acre than paddy allowed to remain standing in the field to sun dry. This optimum harvest moisture level varies with varieties and must be experimentally determined for local varieties before pertinent recommendations can be made for ideal harvest moisture percentage.

10. Experience in the Tanjore District, south India, has also shown paddy can be harvested and threshed by hand, at high moisture levels just as easily as at low. This practice has now been used for several years, overcoming the traditional practice of "threshing sun dried paddy only".

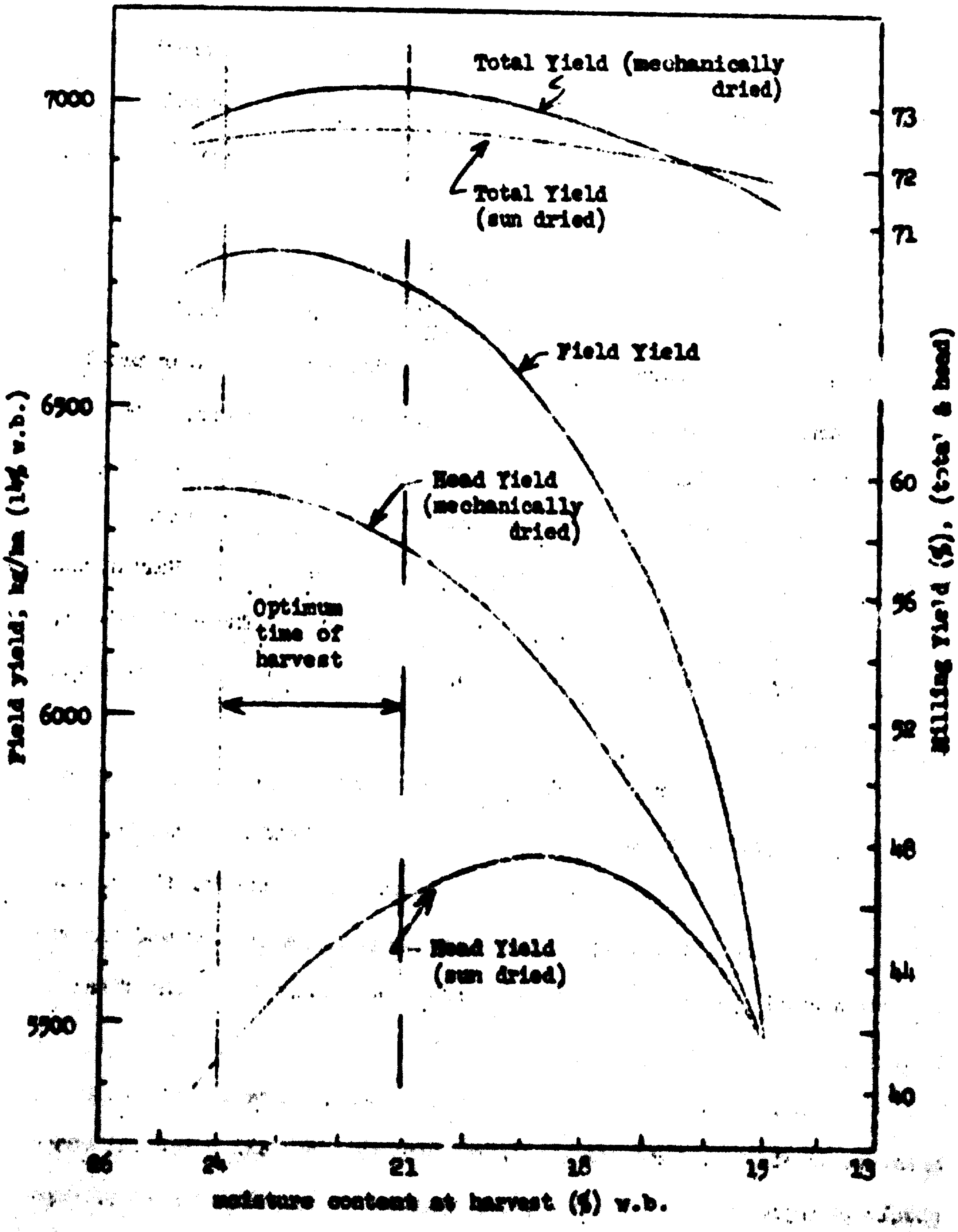


FIG. 1. EFFECT OF MOISTURE CONTENT AT HARVEST ON FIELD YIELD AND MILLING YIELD OF IR-8 PADDY VARIETY

11. Several authors (5, 6,) have reported mechanical threshing of paddy produces a cleaner paddy. The common practice of threshing on a threshing yard or road site does not land itself to easy paddy cleaning. Instead paddy threshed under these conditions tends to have excess quantity of dirt, stones and straw along with the paddy.

12. Several studies, including IRRI (5), report the growing labor shortage during paddy harvest season. With this critical labor problem, more emphasis is being made on the use of mechanical threshers. Due to the small size of paddy fields in the Sub Continent, and the difficulty of utilising large self-contained harvesters-threshers, more emphasis is being devoted to developing small portable, threshers. Both Harrington (6) and IRRI (5) have developed improved paddy threshers. These threshers, developed for Asian conditions provide an economical means to thresh and produce a cleaner paddy.

13. Clean paddy produced from improved harvesting-threshing operation also reduces drying, storage and handling costs. This in turn, reduces the overall processing cost and provides a greater income for the grower.

14. Thus the first step in paddy processing, harvesting and threshing has a considerable effect on the quality and quantity of the final product, rice.

15. Paddy should be harvested and threshed at a relatively high moisture level, i.e. immediately after maturity; and all practical means should be employed to thresh the paddy by hand or by machine - to produce the cleanest possible product.

II

Drying

16. Throughout Asia paddy is harvested at 16 to 26% moisture level. It must then be dried to a level of 12 to 14% for safe storage and future processing. Paddy stored "wet" decomposes and/or is attacked by micro-organisms and turns yellow from heat damage. Some varieties, with a short or no dormancy period will germinate if stored wet (7) (8). All these factors cause deterioration in the quality of paddy, thus reducing its value as an edible product.

17. To protect the quality of paddy after harvesting, it must be dried properly before storing. Traditionally, paddy is sun dried in most of Asia. This is done in the field while the paddy is standing before harvesting, or by spreading the freshly harvested paddy on the "drying yard" and stirring it until it is dry. The sun drying practice, usually results in a combination of drying and wetting due to rain and changes in relative humidity between day and night and causes sun checks on the rice kernel. During milling these sun checks fracture, causing many small pieces of the rice kernel to be lost with the bran and husk. The result is lower head rice yields and lower total returns during milling.

18. Faulkner reports (4) that a drying test in Dokri, West Pakistan, shows the following:

Test Lot	Drying Method	Rice Recovery-% Head	Rice Recovery-% Total
1.	Open sun	21.3	45.7
2.	Thatched huts with open sides	41.4	52.6
3.	In a closed room	52.7	71.3

19. This data illustrates the tremendous differences obtained between methods of drying and the advantages of "controlled drying" over sun drying. Controlled drying in thatched huts or under shade is practiced on a very limited scale. To overcome the disadvantages of sun drying, mechanical drying of paddy is being used in some areas. Mechanical drying of paddy is done in bins or in continuous flow dryers, where heated air is blown through the paddy.

20. Studies have been conducted on several Indian varieties to determine the difference between sun drying and mechanical drying.

The Rice Process Engineering Center at Kharagpur reports (3):

Variety	Moisture Content at Harvest (%)	Head Yield (%)		Total Yield (%)	
		Sun Dried	Mech Dried	Sun Dried	Mech Dried
ADT-27	23.2	63.8	72.8	70.4	73.4
ADT-27	15.5	66.2	-	70.0	-
IR-8	24.8	38.9	59.6	72.3	72.6
IR-8	15.0	42.4	-	71.9	-
CO-25	21.8	51.2	62.3	74.6	75.0
CO-25	15.5	40.7	-	71.8	-

21. "Total yield for mechanical dried samples of IR-8 variety was 72.6% when harvested at 24.8% moisture and was only 71.9% when harvested at 15% moisture content. The head yield for IR-8 was 59.6% when harvested at 24.8% moisture and was only 42.4% when harvested at 15% moisture. Other varieties show similar difference."

22. The second phase of this study was to evaluate the effect of drying methods on the milling quality. The results of IR-8 is shown in Fig 1. The total milling outturn of IR-8 was 73.3% when mechanically dried and 72.3% when sun dried. The head yield for mechanically dried IR-8 was 59.6% and the head yield for sun dried IR-8 was 38.9%. This shows a considerable improvement in the quality of rice when the paddy is mechanically dried instead of sun dried.

23. On other varieties, ADT-8, the mechanically dried sample gave 3.34% more total rice yield than the sun dried sample. On still another variety, CO-25 the mechanical dried sample gave 11.1% more head rice than the sun dried sample.

24. On IR-8, the total rice outturn of paddy harvested at the optimum moisture level and mechanically dried was 4940 kg/ha of mechanically dried and 2320 kg/ha for sun dried samples.

25. Using the 1969 paddy and rice prices in Tanjore District, these differences mean Rs. 800 ($107.00) per ha.* This economic advantage could be divided between the grower and the miller. The grower, obtaining more paddy yield per acre could gain Rs. 595 per ha and the miller could gain, due to increased milling yields, Rs. 205 per ha.

26. The use of mechanical drying of paddy has other advantages besides the increased field yield and milling outturn. Mechanical drying provides facilities for harvest and drying during monsoon and rainy seasons. Also the farmer can harvest his paddy crop 10 - 16 days earlier, which is greatly beneficial to double and triple cropping areas.

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* Indian Rs. = 7.5 per U.S. $1.00

27. A large number of LSU type multi pass continuous flow dryers are now being used in south India. These dryers, complete with conveying systems, scalpor cleaners, tempering and storage bins provide a quick and economical means for mechanically drying paddy. Scalpor cleaners are used preceeding the mechanical dryers. They remove most of the foreign material from the paddy, making the drying operation more efficient.

28. Batch or bin drying on smaller scales are being studied for the farmer and village level operation. The Rice Process Engineering Center has constructed, and are now field testing, one ton batch dryers and one ton recirculating batch dryers. These dryers can provide the facilities for a farmer to benefit from early harvest. Other types of drying processes are being studied (9, 10) to learn more economical drying methods. Faulkner reports (10) that Infra-red dryers reduce the drying time for paddy by 60 - 80%. As soon as this type dryer is developed for field operation it will provide a new dimension to paddy drying in Asia.

29. Rao reports on the cost of mechanical drying in south India (11) using the multi pass continuous flow dryer. Installation of a number of mechanical drying centers in south India by the Food Corporation of India were completed in 1967. The operation of these mechanical dryers has provided a means of evaluation of the operational problems and economics of mechanical drying. Rao reports that when these centers are operated at 2/3 their designed capacity (90 tons per day and 100 working days per year) the drying cost is Rs. 10.33 ($1.38) per ton. When the drying center is operated at its designed capacity of 160 tons per day for 120 days per year the drying cost is reduced to Rs. 5.8 per ton ($0.77).

30. Other experiences with the same type of multi pass dryers in south India show drying cost for field paddy to be approximately Rs. 12 per ton ($1.60); and for drying parboiled paddy, Rs. 16 per ton ($2.13). Very little information is available on the total cost of sun drying. Such costs include labor, drying yard construction and maintenance, losses to birds and rodents and the contamination of paddy with foreign material. The difference in cost between sun drying and mechanical drying is greatly offset by the improved quality and quantity of head rice which mechanical drying has demonstrated as superior to sun drying.

31. In order to obtain the benefits of mechanical drying many changes in the traditional harvesting and drying processes must take place. The farmer, must learn to harvest the paddy immediately after maturity at a high moisture level. Paddy must then move immediately either to a commercial mechanical dryer or to a farmer or village level mechanical dryer. The miller or trader subsequently must learn how to operate a mechanical dryer. Experience in south India has shown a transport - procurement system must be employed with a commercial dryer - in order to operate it on an economical basis.

32. Drying precedes storage and follows parboiling. Therefore commercial dryers should be attached to a paddy storage system. Where parboiling is carried out mechanical dryers may be connected to the plants.

33. It appears to be practical and economical for farmer to use small one to two ton batch dryers. These dryers consist of simple construction with small blower and heaters. These dryers can be built of local materials in the paddy growing area of India.

34. Multi pass continuous flow dryers of various sizes are now being manufactured by several firms in India. The dryers being fabricated are LSU type with holding capacities of 6, 10 or 15 tons. They are used with complete mechanical handling systems, tempering bins for the multi passes operation, and with storage bins.

35. Using these dryers with an air temperature of 160 - 170°F, we are able to reduce the moisture of paddy an average of 2% per pass. Paddy received at 20% moisture and dried at 14%, requires a 6% reduction and consequently uses three passes.

36. This same type dryer is being used to dry parboiled paddy, which may contain as much as 36% moisture following parboiling. The operation for parboiled paddy is somewhat different, in that the paddy is continuously recirculated in the dryer for two hours giving each kernel of rice four passes (based on 1/2 hour per pass) before it is tempered. For the smaller batches of parboiled paddy this method has been used. Two such operations are needed to reduce the paddy moisture to 14%.

III

Storage

37. Traditionally in most of Asia paddy is marketed soon after harvest. The paddy is bagged in gunnies and moved to various storage facilities, ranging from mud huts to large commercial godowns (warehouses).

38. Most storage structures fail to maintain quality and quantity of the paddy and incur heavy losses. Losses of 5 to 10 percent of paddy in storage were reported from a survey by the Asian Productivity Organization (12). Many reports showing similar losses have been recorded by various other organizations.

39. Mr. S. V. Pingale (13) of the Food Corporation of India reports: "Wide variances in estimates (3 - 50 percent) of storage losses are rendered possible by different interpretations, particularly of the loss of quality. Precise methods for assessment of qualitative loss do not exist. Work is in progress for development of a standard technique at the international level under joint auspices of International Standards Organizations and International Association of Cereal Chemistry and at the national level through Indian Standards Institute".

40. During the traditional storage process, little attention is given to "keeping quality". Often the stored paddy is infested with insects, or mould growth, each of which deteriorates grain quality and quantity rapidly. Other losses during storage are due to rodents, birds, and pilferage. The grain moisture content, percent foreign material and grain respiration affect storage losses.

41. To safely store paddy, it first, must be free of insects, mould growth, and be clean and dry. The condition of the grain to be stored must be of the highest quality. Considering this, then the storage structure must be designed and equipped to maintain quality and quantity during the storage period.

42. In an attempt to reduce storage losses, India is now using two types of improved storage methods. One is improved godowns which are constructed with the floor well above ground level, moisture proof walls and roof, rodent proof, and designed for fumigation. The paddy is still stored in the gunny bags and has a large labor requirement for loading and unloading.

43. The second type of storage is the use of silos with mechanical handling equipment. In these silos the paddy can be stored safely, free from insects and easily aeriated or fumigated. Losses due to rodents, birds or pilferage are negligible.

44. Bulk silo storage can be constructed to almost any capacity required, and from various materials. Reinforced concrete and pre-fabricated metal silos are generally the least expensive building materials. The silos are easily constructed with capacities of a few tons to several hundred tons.

45. With bulk storage, aeriation and temperature detection equipment must be provided to safely keep the grain.

The main objects of aeriation are: (14)

1. to lower grain temperatures (to cool a mass of warm grain entering after drying or harvest at high temperatures);

2. to equalise grain temperature through the bulk (to eliminate localised heating ;

3. to remove unpleasant odors or toxic gases after fumigation; and

4. to reduce moisture content by very small amounts.

46. The airflow rates adopted for aeriation are in the order of 0.1 cubic meter of air per minute per ton of grain.

47. The temperature detection equipment usually consist of thermo-couples inserted at regular intervals in the grain mass. An instrument outside the grain mass indicates the "temperature" related from the thermocouples. This system provides the means for a daily check on the grain temperature throughout the grain mass. Any changes in the grain temperature can thus be detected and fumigation or aeriation can then be used as needed.

48. Building costs and operation costs vary considerably with location, labor and material costs. Godowns for gunny bag storage are costing Rs. 150 - 200 ($21.00 to $28.00) per ton to construct. Operation cost is high, due to the depreciation of the gunny bags, and labor to stack the gunnies and remove the bags.

49. Silos in India are now costing Rs. 150 - 220 ($21.00 to $30.00) per ton to construct, including the mechanical handling equipment. Since gunny bags are not used and labor is replaced with the mechanical handling equipment, the silo operation costs are usually less, than godown operation costs.

50. An example of a recent study for a particular storage installation of 4000 tons in West Bengal, India is:

		Silos	Godowns
I.	Investment Cost* (Silo at Rs. 220 per ton and godown at Rs. 170 per ton)	Rs. 8,80,000	Rs. 6,80,000
II.	Operation on Cost (one year)		
	1. Staff salaries	7,200	7,200
	2. Labor wages	-	8,000
	3. Electricity	2,400	1,200
	4. Maintenance	8,800	13,600
	5. Depreciation	17,600	20,400
	6. Interest on investment	66,000	51,000
	7. Gunnies cost	-	22,390
	Total:	Rs. 1,02,000	Rs. 1,24,290
III.	Storage cost per ton per month	Rs. 2.12 ($0.29)	Rs. 2.59 ($0.35)

* Indian Rupees, Rs. 7.5 = $1.00

51. The preceeding storage cost calculations reflect the (1) high cost of maintenance of godowns constructed in India and (2) the additional cost of gunny bags and the labor to stack and remove the gunny bags from the godowns. This calculation does not take into consideration any storage losses of the paddy. It is expected the godown will incur losses of 2 - 5% more than the silo storage, which would account for even a greater difference in storage costs.

52. The design storage capacity of a paddy processing plant depends on (1) the milling capacity of the plant (tons per day or per month); (2) the paddy procured per month and (3) number of crops harvested per year. An example of a storage requirement is:

Storage Capacity Design: Rangunia Thana Central Co-operative Association, Chittagong, East Pakistan

I. Expected Paddy Procurement Program:

1. Boro Season: Harvest and procurement season 15 May thru 15 July, 4000 tons

2. Aus Season: Harvest and procurement season 15 July thru 15 September, 2000 tons

3. Aman Season: 15 November thru 15 February, 6000 tons.

II. Design mill capacity 1000 tons per month.

III. Monthly Procurement, Milling and Storage requirements:

	Paddy Procurement	Paddy Milled	Paddy Stored
January	2400	1000	2800
February	600	1000	2400
March	-	1000	1400
April	-	1000	400
May	1200	1000	600
June	2000	1000	1600
July	1300	1000	1900
August	1000	1000	1900
September	500	1000	1400
October	-	1000	400
November	600	1000	-
December	2400	1000	1400

53. The maximum monthly storage requirement is therefore 2800 tons and the storage design should be based on this capacity.

54. The selection and final design of any storage structure will depend on (1) labor to be used, (2) cost of building materials and the construction, (3) cost of power for mechanical handling operation, (4) cost of gunnies and (5) cost of land, (6) cost of management or supervision.

55. Pingale also reports (13): "It is suggested that storage not be considered in isolation but along with other problems related to post harvest period. These problems are marketing, quality assessment, transport, and storage. Mechanized bulk storage is relatively loss-free. For adoption of this, however, marketing is required to be mechanized and methods of quality assessment modernized. A bold step to counter resistance from traditional agencies is considered necessary to adopt this modern type of storage.

56. Again the storage structure requirements are: a structure that will safely keep paddy free from deterioration in quality and quantity.

IV

Parboiling

57. Parboiling paddy is a process of soaking and steaming the paddy before milling. The Central Food Technology Research Institute, reports: "Parboiling of rice is a long established traditional practice in India. The importance of parboiling is that this process gelatinizes the starch and thus solidifies the fractures in the rice grain. Breakage of the grain during milling is minimized. The yield of head rice is increased by 5 - 10% in the case of durable paddy varieties and more on weak varieties. The yield of total marketable rice is also increased by 1%. Parboiling also results in the grain having a higher content of vitamins and minerals than raw rice, thus the nutritional quality of rice is enhanced". (15)

58. Mr. Gariboldi (18) describes parboiling of paddy as: "Moisture and heat, make alterations to the grain which research has defined as: during steeping, the water soluble substances in the outer layers spread towards the starchy endosperm, water absorption also causes the outer layers to become uniform and facilitiates heat penetration toward the middle of the grain. Due to the effect of heat, the starch in the endosperm gelatinizes and seals any cracks present in the endosperm itself. This gelatinisation may be described as a change in the condition of the starch which becomes pasty instead of granular".

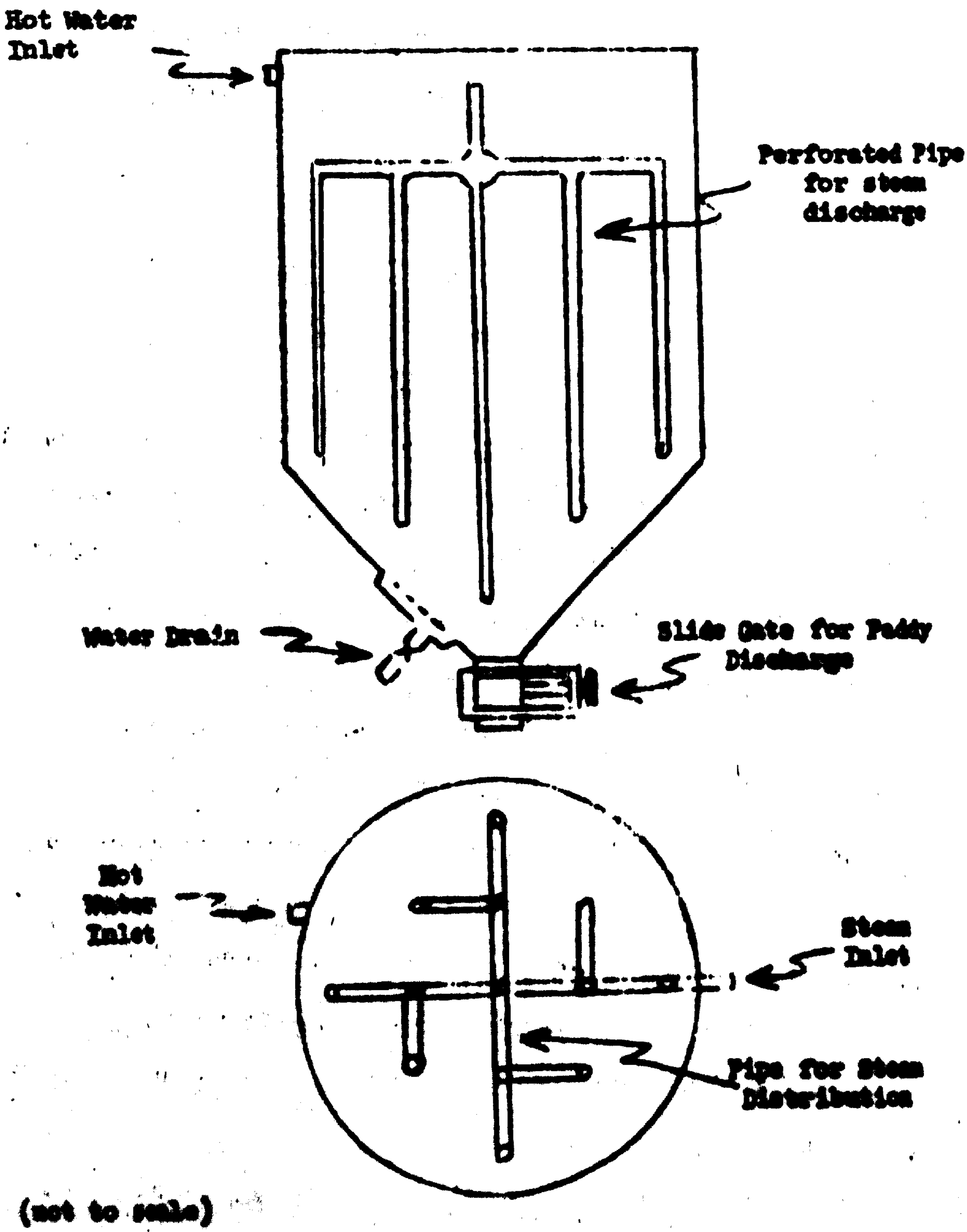
59. Approximately 40% of the marketable paddy production in India is parboiled. This is a practice in particular areas, where the consumers prefer parboiled rice. The increased head and total rice yield

with traditional milling methods of parboiled rice, this has become an accepted practice; thus promoting an "eating habit" by certain groups. Parboiling of paddy is practiced in other Asian countries on a limited scale, for instance, Ceylon, Pakistan, Nepal and Burma.

60. A number of traditional methods of parboiling have been used for many years (15, 16). These methods generally consist of soaking the paddy for 2 - 4 days, then boiling the paddy for a short period of time. Different types and sizes of soaking tanks and steaming kettles have been used in these methods. In some areas of Asia, the "chatti" method is still used. The Chatti is a clay pot, holding ½ maund (41 pounds) of paddy. The paddy and water are placed in the chatti, then a fire is built around the chatti with paddy husk or sawdust. After the paddy is soaked and "cooked" in the chattis it is removed and steamed over an open fire in a large metal pan. Each of the traditional methods of parboiling, employ a large labor force and is time consuming, thus a larger unit cost of parboiling. These methods also tend to ferment the paddy and produce a disagreeable color and odor.

61. The Central Food and Technological Research Institute, Mysore, developed a process which reduced the soaking time to a few hours and steaming to a few minutes (15). This method is now being used by a number of millers in different parts of India and is being rapidly adopted by others.

62. The equipment for the modern method consists of a simple parboiling tank (Fig 2) holding 3 - 6 tons of paddy (depending on the desired capacity). Raw paddy is placed in the tank and kept in hot water at 70 - 75°C. for two to three hours. The soaking water is kept



PARBOILING TANK

FIG. 2

hot by recirculating the water in a hot water tank - where a steam heat exchanger is used to heat the water. After soaking the paddy, the water is drained from the tank. The paddy is then steamed by injected steam in the paddy through a series of steam pipes in the same tank. After steaming for 20 to 30 minutes, the paddy is discharged from the tank and is ready for drying. The paddy after soaking and steaming contains approximately 35% moisture and must be dried to 14 - 15% moisture level before milling. This process produces a uniform, high quality parboiled paddy. Variations in the appearance of parboiled paddy or degree of parboiling is achieved by varying the time of soaking and steaming (15).

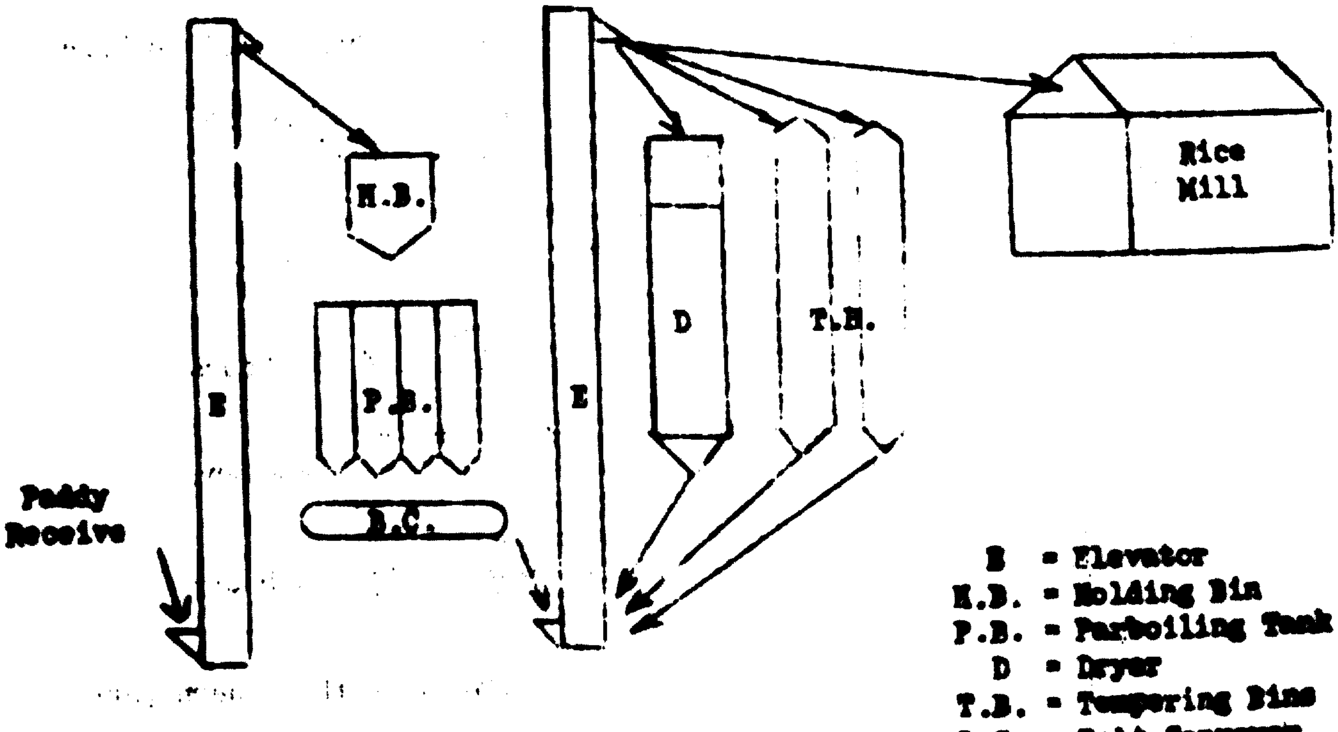
63. The flow diagram and layout of a typical 48 ton per day parboiling plant is shown in Fig 3.

64. The cost in India of a 48 ton per day parboiling plant is approximately Rs. 1,70,000 ($23,000). This includes the parboiling tanks, supporting structure, conveying equipment and a mechanical dryer.

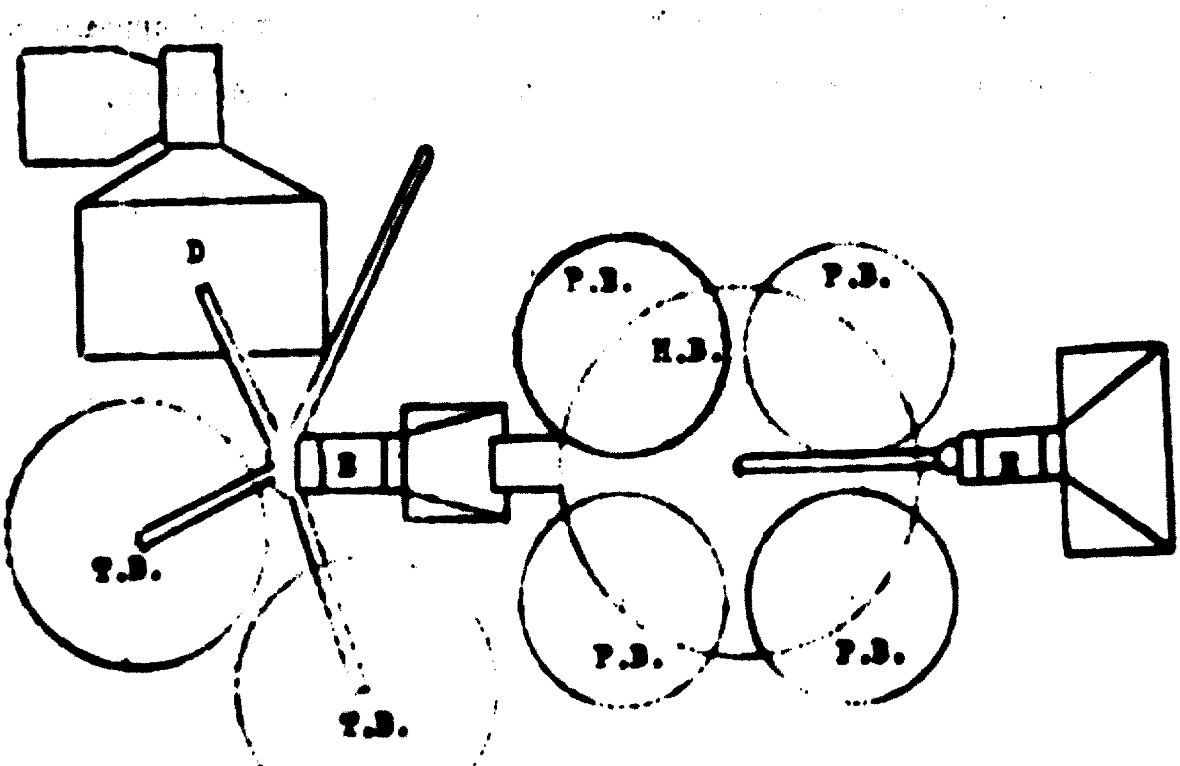
65. The operation schedule is based on the maximum utilisation of the equipment through a 24 hour working day. This reduces the per hour steam requirements to a minimum. The Food Corporation of India has estimated the steam requirements for parboiling to be approximately 200 kg's steam per ton of paddy.

66. Therefore for a 48 ton per day parboiling paddy plant requires 9600 kg of steam per day. For most operations the parboiling is carried out in 12 hours. This requires a boiler of 800 kg per hour capacity.

67. A practical installation includes a husk fired boiler. Husk is produced in the rice mill, and has little or no value for other



FLOW DIAGRAM



LAYOUT

FIG. 3 PARBOILING SYSTEM

purposes, it is an inexpensive fuel for the boiler. Husk fired boilers are available from several manufacturers, and cost approximately Rs. 1,00,000 ($14,000).

The drying schedule for parboiled paddy consists of:

1.	recirculating the paddy in the dryer which reduces moisture of the paddy from 36% to 20%	3 hours
2.	holding the paddy in a tempering tank - where it is allowed to temper for	6-8 hours
3.	repeating the drying operation; which reduces moisture of the paddy from 20% to 14%	3 hours

68. The mechanical dryer being used in India with the modern parboiling system is a LSU continuous flow type. The parboiled paddy is continuously recirculated through the dryer during the drying operation. This method of parboiling with the equipment described appears to be one of the most practical and economical methods of parboiling.

V

Milling

69. Milling of rice, is the step in rice processing, of removing the husk and outer bran layer of rice and producing an acceptable white rice. In many parts of Asia this is still being done in the villages by hand pounding. This is a simple but crude method of removing the husk and some of the bran layer. Much of the paddy is broken during the process and the small brokens are lost in the husk and bran. Hand pounding has a low milling outturn, and a non-uniform degree of milling.

70. The machinery and techniques for milling may be divided into a number of steps:

Cleaning → Dehusking → Husk Separation → Paddy Separation → Polishing → Grading

71. Paddy received at the rice mill is first cleaned to remove all foreign material; dust, straw, rocks, etc. Paddy cleaners use vibrating sieves, rotating sieves and air aspiration to separate foreign material from the paddy. After cleaning the paddy is fed to a dehusker, where the husk is removed from the paddy grain.

72. Three types of dehuskers are now being used in India and most of Asia. The traditional "huller" is one of the earliest mechanical machines for removing husk. Hullers are relatively small units, with a throughput capacity of 250 - 300 kg per hour. The huller machine accomplishes the dehusking of the paddy and the polishing. In small village mills the milling may be done in one or two passes through the huller. In larger mills, three to five hullers are operated in series to accomplish the dehusking and the polishing in steps. The huller mixes

the bran with the husk. This does not provide a high quality bran and the husk-bran combination is used for cattle feed or fuel.

73. The huller rice mill usually incorporates a paddy sieve and aspirator to separate the brokens and husk from the head rice. This unit has a high labor requirement since the paddy is usually fed into the huller by hand, removed from each huller and fed to the next huller by hand, and separated by hand.

74. The second step to mechanizing rice milling was the introduction of the "under run disk sheller" rice mill. This may be termed a unit mill, since it incorporates a paddy cleaner, a disk sheller, a paddy separator, a cone polisher, and a rice grader. This mill was the first attempt to divide the milling steps into different machines. The under run disk sheller does the dehusking of the paddy. After the brown rice is separated in the paddy separator, it is then polished in the cone polisher.

75. Today, the modern dehusker is a rubber roller sheller. Paddy is passed between the surface of two rubber rollers, turning at different speeds and the husk is removed from the paddy with the least amount of damage to the paddy grain.

76. The husk separation is usually accomplished with aspiration systems. As the dehusked paddy and husk come from the dehusker, air is blown through the mixture and it separates the husk from the brown rice (dehusked paddy).

77. Since not all of the paddy is dehusked in the first pass through the dehusker, the unhusked paddy must be separated from the dehusked paddy. This is accomplished with different types of paddy separators.

78. Since the specific density of dehusked paddy is different from husked paddy - the vibrating table, easily separates the two components. The dehusked paddy then returns to the dehusking unit.

79. The clean brown rice (dehusked paddy), is then fed to the whiting machines or polishers. Here the brown rice moves between perforated screens and abrasive cylinders. During this process, the bran or outer layer of the rice is removed. The time the rice kernel stays in the polisher determines the "degree of polish" or the percent of bran removal. Since the bran moves through the screens, it is separated from the polished rice. The bran is then collected for other by-product uses.

80. The polished rice then moves to a "grader" where the different size brokens are separated. Separations are generally made in three classes: (1) Head rice which are kernels 3/4 in size or larger, (2) large brokens, 1/2 to 3/4 in size and (3) small brokens - less than 1/2 size of full kernel.

81. Following the grading operation the milled rice is bagged for storage or shipment to market.

82. The Government of India began a pilot, demonstration modern rice mill program in 1965 (19). This author was honored to be the Technical Advisor to the program, from 1966 thru 1970.

83. This program established seven units. Each unit incorporated modern mechanical handling, mechanical drying, silo storage, modern parboiling and milling. All of the equipment used in this program was manufactured in India except the milling machinery. This was imported from manufacturers in Germany and Japan. The seven pilot units included 1 [illegible], 2 [illegible] and 4 [illegible] rice mills.

84. After the mills were in operation, the Food Department of the Government of India established an evaluation team. This team studied the rice outturn of the modern rice mills and the different type of traditional rice mills. A summary of their report is (20).

1. - For raw paddy, the modern mills gave an overall average increase in total rice outturn of 2.5% over sheller type mills and 6.6% over huller mills. The actual increase varied from 0.8 to 4.4% over sheller units and 1.8 to 12.6% over huller units.

2. - For parboiled paddy the corresponding increase in total yield for the modern mills averaged 0.8% over the sheller mills and 1.6% over the huller mills. The actual figures varied from 0.0 to 1.8% over shellers and 0.3 to 2.5% over hullers.

3. - For raw paddy the increases in head yields in the modern mills over sheller mills varied from 2.0 to 10.4% with an average of 6.1%. Compared to huller mills, the increase varied from 6.9 to 24.9% with an average of 15.1%.

4. - For parboiled paddy, the increase head yields over sheller mills varied from 0.8 to 2.7% with an average of 1.6%. The increase over huller varied from 2.1 to 8.5% with an average of 4.1%.

85. From the experience of these pilot rice mills, Indian firms have collaborated with Japanese and German firms and are now manufacturing the modern milling machinery in India. Other Indian manufacturers are now manufacturing conveying equipment, scalpers, cleaners, dryers, and all other associated rice processing equipment.

86. Several economic comparisons have been made to determine the differences in rice outturn and the investment and operation costs. Table I shows a typical economic comparison.

Table I

Cost and Returns of Modern Rubber Roll Rice Mill and Disk Sheller Rice Mill[1]

	Modern Mill	Sheller Mill
Investment cost	Rs. 90,000	Rs. 65,000
Annual operation cost[2]	46,000	30,000
Paddy investment[3]	30,00,000	30,00,000
Total annual investment	30,46,000	30,30,000
Rice sales[4]	33,60,000	32,64,000
Annual returns	3,14,000 ($41,866)	2,34,000 ($31,200)

1 Indian Rupees: Rs.7.5 = $1.00

2 Operation cost for both mills includes: power, labor, overhead, maintenance, depreciation and interest. The modern mill cost also include Rs. 16,000 for replacement cost of rubber rollers.

3 6000 tons of paddy at Rs. 500 per ton.

4 Modern roller mill 70% rice outturn at Rs. 800 per ton. Sheller mill 68% rice outturn at Rs. 800 per ton.

87. This comparison is for the rice mill only. It does not reflect the cost or returns of mechanical drying, storage, or parboiling. Neither does it reflect the difference in quality of rice outturn, since the market value of rice was fixed price on a Fair Average Quality (FAQ).

88. One attempt to analyse the returns of different size rice mills of 2, 5 and 10 TPH capacity (21) follows. This includes investment cost, operation cost and returns for three processing plants. The plants include storage, drying, handling, parboiling and milling facilities.

		2 TPH	5 TPH	10 TPH
1.	Operation cost per ton*	Rs. 20	Rs. 15	Rs. 13
2.	Capital cost of plant	Rs. 23 Lac	Rs. 48 Lac	Rs. 91 Lac
3.	Annual investment	Rs. 39 Lac	Rs. 97 Lac	Rs. 192 Lac
4.	Annual net margin	Rs. 6 Lac	Rs. 17 Lac	Rs. 36 Lac
5.	Ratio returns to annual investment	Rs. 15%	17%	18%

* Pakistan Rupees March 1969. (Rs. 4.8 = $1.00)

(Lac = 100,000)

89. From this analysis it appears the larger size processing plant (TPH) is more economical and yields a greater return on the investment and on the annual operation cost. This figure alone should not be the deciding factor on size of mill to recommend. One of the most important considerations is the availability of paddy, the procurement program and transportation facilities within the procurement area. Often it is advisable to locate a number of receiving centers or collection points within the paddy production area. At these points paddy may be collected and later transported to the mill site. It may be practical and economical to locate some drying and storage facilities at these collection points. All these factors should be considered carefully before a final selection is made.

90. It may be concluded that modern rubber roller type rice mills offer an economic incentive to the investor. They have the ability to produce a higher quality rice and yield more rice outturn for the same paddy input than the traditional disk sheller rice mill.

VI

Related Factors

91. The operation of a modern paddy-rice processing system is a complex industry. It involves: procurement programs, transportation systems, drying, storage, milling facilities and rice marketing programs.

92. Careful planning and implementation of policies related to procurement, storage, and marketing programs are essential to a successful processing program.

93. In many countries of Asia, the food deficiency situation has caused little attention to be given to grain "quality". With the introduction of modern rice processing, high quality rice is now available to the consumer. This quality far exceeds that of rice produced in traditional mills. The rice is more uniformly polished, cleaner, less brokens, and free of foreign material. This high quality of rice is reflected in the free markets with a premium paid for the higher quality rice.

94. With the modern rice mills the rice miller is now capable of producing this high quality rice. More attention should be directed to marketing this rice, especially to price differences of the different grades of rice now available. With the change from traditional processing to a modern processing program changes in rice marketing are also essential.

95. From the experiences with the modern rice processing program in India there are three essential parts to the success of the program; (1) modern equipment and methods, (2) trained operators and technicians, and (3) trained management.

96. Modern equipment may be imported or manufactured locally. All the modern equipment needed is available from several countries. If manufacturing facilities are available in the country, the opportunity exists to assist the manufacturers in developing most of the equipment. Therefore, the first ingredient, equipment, can be made available.

97. The second ingredient, trained operators and technicians, must be planned. Resources for training, or sending personnel for training should be carefully considered with any initial planning of the program.

98. Trained management is required. Either locally trained personnel or training programs should be used. Any part of this complex industry left to unskilled management or operators, could result in failure to obtain the results of a modern plant.

99. It is recommended that planning of a modern rice processing program include detail planning of the equipment to be used, where it will come from, the training of technical personnel and the management required.

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