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LIBERIA
RICE VALUE CHAIN

VALUE ADDITION TRAINING MANNUAL

(RICE PROCESSING, GOOD MANUFACTURING PRACTICE (GMP), QUALITY/SAFETY, MARKETING AND PLANT MAINTENANCE)

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THE LIBERIA RICE VALUE CHAIN TRAINING MANUAL

The Liberia Rice Value Chain Value Addition Training Manual serves as an important tool for providing training rice value chain stakeholders. It is important for forming strong linkages for actors along the rice value chain. The concept of value addition at each segment of the value chain is well explored from farm to the consumer. The manual helps the operators to understand their role in complimenting the effort of their neighbouring value chain members either before them or after them thereby strengthening the chain. Since the chain can only be as strong as its weakest link it is important that each operator's activity promotes the profitability of all other stakeholder and improve overall sustainability.

The manual also provides details of a wide range equipment, systems and technology tools for processing, food safety, personnel safety, waste and environmental management and for quality management. The basic food plant and equipment maintenance is sufficiently covered in simple language for the user. The manual also covers the areas of business opportunities, consumer perception, packaging and relationship with farmers.

The author is grateful to the Hon. Minister of Agriculture, Liberia, the President and officers of the Africa Development Bank (AfDB), the Coordinator of SAPEC and the entire SAPEC team. My gratitude also goes to all Liberian farmers, rice processors and marketers. Many of them provided very useful information that guided the production of this manual.

It is my hope that the Liberia Rice Value Chain will grow to self-sufficiency in the coming years with strong viable businesses and optimal contribution to national food security.

Dr, Chijioke Osuji

LIBERIA RICE VALUE CHAIN

PROCESSING TRAINING MANNUAL

(RICE PROCESSING, GOOD MANUFACTURING PRACTICE (GMP), QUALITY/SAFETY, MARKETING AND PLANT MAINTENANCE TRAINING)

BY

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INTRODUCTION

Rice is the major staple food for Liberia. Rice is cultivated in all counties of the country to varying degrees. But over 60% of the rice consumed in Liberia is imported. This constitutes a heavy drain on the economy of the country. The Government of Liberia (GoL) has been implementing policies aimed at diversification her economy. Agriculture has been identified as a major means of achieving the diversification. Therefore the GoL is promoting agriculture development by supporting the expansion of various agriculture commodity value chains including rice. The Liberia Agriculture Transformation Agenda (LATA) is supporting rice as well as cassava, cocoa, oil palm, rubber, fisheries (aquaculture/marine) and poultry/livestock through the agricultural value chain approach by October 2017. Its goal is economic diversification and creating the conditions for Liberia to achieve a higher level of economic resilience and inclusive growth.

As part of the measures to develop the plans for boosting the rice value chain and for achieving the rice value chain, the Ministry of Agriculture of Liberia hired a short-term Rice Value Chain Consultant to develop plans for the paddy aggregation and rice processing centers for rice in Liberia within a period of 5 months. The consultant - Dr. Chijioke Osuji assumed duties on 26th September, 2016. He is working under the supervision of the Office of the Minister of Agriculture and reporting to the Project Management Unit (PMU) of the Ministry of Agriculture.

One of the major assignments being carried out by the consultant as part of his major objectives is the development of a Rice Processing Training Manual. This manual is based on a value chain approach and includes to the areas of the value chain that influence or is influenced by processing.

It is known that modern civilization thrives on science and technology. Technology supports industrial development. Technological advancements are promoted with experience and training. Capacity building and development of knowledge base has become imperative for the different aspects of industrial growth including agriculture. Therefore sustained training of agriculture stakeholders will eliminate manifestations of ignorance from the conduct of their activities and improve efficiency. This could be achieved by organizing regular trainings for stakeholders in the relevant areas of their practice. By doing this, they stand a chance of remaining viable as trends unfold in their various fields. It is thus inevitable that rice stakeholders must be upgraded regularly in order to embrace international best practices that would result in new ways of doing things for customer satisfaction. Equipment and processes never cease to become more sophisticated. Producers and consumers alike are always focused on issues concerning efficiency and safety. The economics of production and marketing remain dynamic and continue to compel stakeholders to seek for alternative and cheaper means for production operations. It is imperative that operators in the industry undergo continuous learning and re-orientation for capacity building and upgrades to meet new standards, regulations and requirements.

LATA recognizes the value of this knowledge enhancement as a way to develop and encourage rice processors and their staff; to increase their knowledge base and for value addition in rice processing.

By providing training support, LATA is desirous to make the rice processors develop and produce high quality rice and rice-based products for local and international markets. The present Training Manual was preceded by a series of scoping visits by the consultant and the team of SAPEC staff to various rice processing operators. The aim was to evaluate the training needs of the firms and to package training for them in line with identified needs.

With a good understanding of the operating principles of well designed equipment, current good maintenance regime, current Good Manufacturing Practices (cGMP); well-structured processing flow, with adequate safety, health and environment observance and practices, it is expected that production capacity will increase and product quality will improve to overcome competition.

The present training is based on the experience acquired from the local operators. It is expected to address the needs of the processors and still be very beneficial to all rice value chain actors.

At the end of the training, participants will be able to:

- Acquire basic business and enterprise development skills for a typical rice processing environment
- Enlarge their understanding of business opportunities and challenges in a rice processing outfit
- Understand the principles of post-harvest handling and storage of rice and other food raw materials and how they apply to the production of high quality pre-packaged rice products.
- Appreciate the function of the equipment used in the processing of rice paddy and to understand the desired qualities expected at every stage of production.
- Apply the best practices in the processing of rice
- Implement a sustainable and well-structured preventive maintenance scheme that will considerably reduce downtime and loss of man hours due to machine breakdown.

- Understand quality parameters related to rice and insist on attaining quality specifications.
- Be fully aware of the need to safeguard machine and personnel by abiding by basic safety, health and environment (SHE) rules.
- Be conscious of hazards associated with negligence of safety rules and wearing of appropriate personal protective equipment (PPE).
- Understand the meaning and relevance of Hazard Analysis, Critical Control Points (HACCP) to their system.
- Be in a better position to start conceiving new products for enhanced capacity utilization.

SECTION 1

ON-FARM POST HARVEST OPERATIONS OF RICE (*Oryza sativa*)

Harvesting and Handling:
To properly study post-harvest handling of rice paddies, it must be understood that it is an agricultural produce and therefore subject to the risks associated with such materials. A basic understanding of the physical characteristics of the rice crop and the growth cycle should prove useful in the handling and processing of the commodity into useful products.

General Information
Rice belongs to the family of cereal grasses, along with wheat, corn, millet, oats, barley, rye, and numerous others. The grass family provides the world with over 60% of its caloric intake and over 75% of the protein for developing nations. Rice remains the worlds' most popular grain.

The rice plant is an annual grass (it normally grows for only a year and then dies) with round, hollow, jointed culms (stems), flat leaves, and a terminal panicle (flower cluster). It is the only cultivated cereal plant adapted to growing in both flooded and non-flooded soils. Grown under a wide range of climatic and ecological conditions on all five continents, it serves as the staple food throughout much of the world. The parts of the rice plant may be divided as follows:

- roots

- stem and leaves

- reproductive organs

- grain

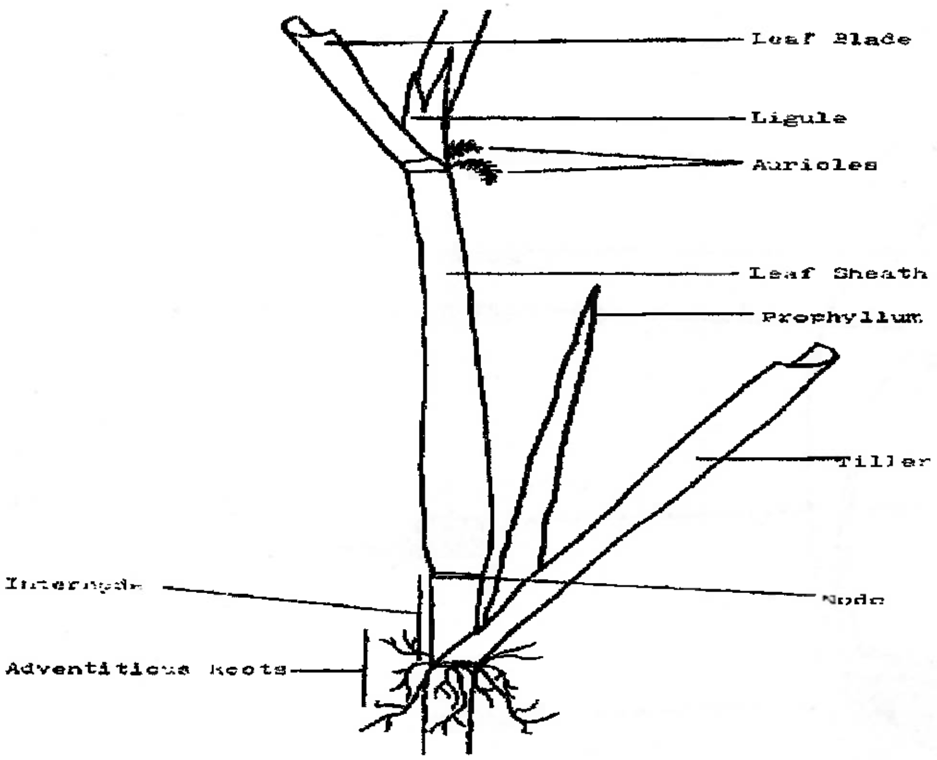

Fig. 1: Stem and Leaves of the Rice plant

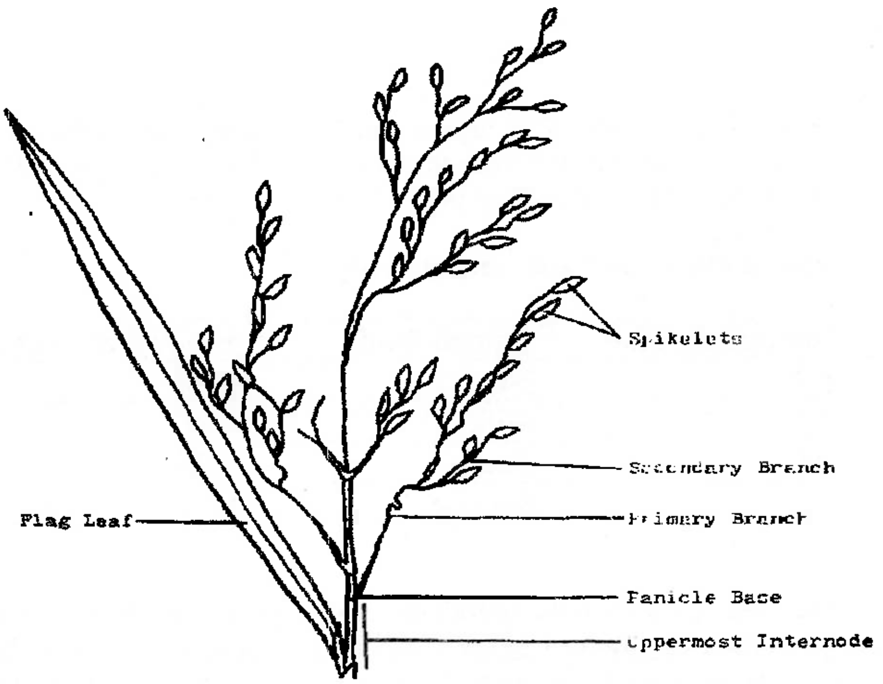

Fig. 2: The spikelets (partly shown)

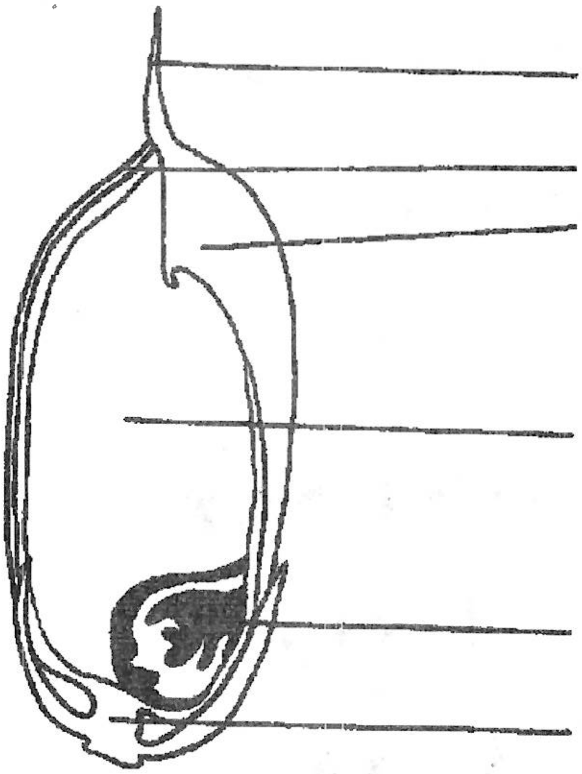

Fig.3: The Rice Grain

Rice contributes significantly to the nutrition of its regular consumers due to the quality of its nutritional composition. Table 1. shows that the biological value of rice compares to that of soybean and rank among the highest compared to other plant foods.

Table 1The Biological Value of Plant Foods and Animal Foods

Vegetable foods	Biological value	Animal foods	Biological value
Milled rice	0.75	Egg	0.94
Flour	0.52	Milk	0.96
Corn	0.60	Beef	0.76
Soybean	0.75	Salmon	0.72

The biological value of the food refers from the nutritional quality of food proteins. It is the relative measure of the proportion of absorbed proteins which is retained by the body. It is related to the composition of the essential amino acids. Regular consumption of essential amino acids is important for the overall well being of consumers. From Table 1, the biological value of rice is comparable to salmon (fish) and beef.

Harvesting

The maturation of rice crop takes about 90-270 days from germination to harvest (depending on variety). During its growth and development, after the reproductive phase the crop enters the ripening phase. From then on the farmer and the processor must exercise care to determine when to harvest. In the first stage of ripening (the **Milk stage**), the endosperm first begins to form as a milky liquid. Rice at the milk stage is very susceptible to attack by sucking insect pests. The next stage is the **Dough stage**, during which the milky liquid begins to solidify into a sticky white paste and bird pests generally begin to be a serious problem. This stage is followed by the **Maturity stage** which is when the grain is mature, or ripe, when the endosperm becomes hard and opaque. While the grains ripen, the leaves of the plant begin to turn yellow as nitrogen is transferred from the leaves to the seed. The full maturity stage is reached when more than 90% of the grains in the panicles have ripened. Mature grains usually undergo a change in color and turn a golden brown, but under wet climatic conditions ripe grains may remain somewhat greenish.

If the grains are not harvested on time, they will go into the **Over-ripe stage** and the vegetative parts of the plant - stems, leaves, and roots - begin to die off. Then the over-ripe grains fall off the panicles onto the ground in a process known as shattering. Some rice varieties are particularly susceptible to shattering, and serious crop losses may occur if harvesting is not completed on time. In rare instances, over-ripe grains left too long on the panicle may undergo germination. Varieties exhibiting -this characteristic are said to lack dormancy.

A major problem in the harvesting of rice is occurs when the fields does not ripen uniformly. At the end of the rainy season, when most varieties mature, frequent rains and a lack of continuous sunshine protract the grain ripening process and make it difficult to properly time the harvesting operations, since grains even on the same panicle ripen at varying rates. If the crop is harvested too early, many green grains will be lost, because the high water content will lead to rotting. If on the other hand, the crop is harvested too late the rice will over-ripen and easily shatter. Furthermore, the unnecessary delay will expose the grains to increased bird attack which can be devastating.

As harvest time approaches, the plants should be inspected daily, particularly the panicles on the most mature tillers. The proper time to harvest is when approximately 85% of the panicles are ripe. "Ripe, means that 90% of the spikelets are golden and hard, yet not so dried out as to shatter easily. The lowermost spikelets on each panicle will ripen last, but even they should be at least at the hard dough stage. The color of the leaves and stems should not be used as an indicator of the ripeness of the grains, since many varieties tend to have some green stems and leaves even when the grains are fully ripened.

Although grain ripening cannot be fully controlled by the farmer (climate and varietal characteristics will always be the major determinants), drain the plots 7-10 days before anticipated harvesting, i.e., when most of the grains are at the hard dough stage. This will contribute to even drying and facilitate harvesting by making it easier to walk inside the plots.

The traditional method of harvesting practiced usually involve local rice farmers involves panicle cutting. Harvesters grasp each stem several inches below the lowermost spikelets and cut it with a small straight knife. The panicle is retained and added to the growing bundle held in the hand. When the bundle becomes awkwardly large, it is tied together with a wisp of straw and carried out of the swamp. The chief advantage of panicle cutting is that the straw remains behind in the field. Bundles of rice produced by panicle cutting are easy to transport, easy to store, and easy to thresh. However, panicle cutting has several distinct disadvantages: it is very time-consuming, and since each panicle is handled frequently many grains shatter (fall to the ground).

However sickle harvesting is also practiced, it is very popular in Asia. It is very fast, since entire bunches of stems are grasped and cut in one swift motion. However, sickle harvesting requires the use of threshing machines – could be the pedal thresher, the threshing table and even the mechanical axil flow or centrifugal threshers. At present few farmers possess threshing machines or know how to build them, so sickle harvesting is the dominant practice.

There is a continuous moisture reduction from 16 to 46 days after flowering; beyond the forty-eighth day, moisture loss becomes negligible and the crop comes into equilibrium with the environment. Normally about a week would pass during which the grains attain moisture content between 20 and 24 per cent. If the crop is harvested during that period, the losses are considerably reduced and the field yields are comparatively high. Maximum yields were actually recorded from the harvest carried out on the thirty-first and thirty-second day after flowering, all field yields being corrected to a fixed moisture content of 14 percent. An appropriate period for harvesting paddy crops may therefore lie between the twenty-eighth and thirty-sixth day after flowering. This provides about nine days to complete the operation without sacrifice of either the yield or quality of the grain. If the crop is over-dried, sun-cracks develop on the kernel and cause breakage during threshing and milling.

Threshing

Rice that has been harvested by traditional panicle cutting is very easily threshed, since very little straw remains with the grains. The harvested bundles of rice are placed on a clean, hard surface and beat with sticks to separate the grains from the straw (dried leaves and stems). Frequently the threshers will walk over the bundles to speed the process. If any grains remain clinging to the straw, they are separated by pounding in wooden mortars.

Rice that has been harvested by sickle cutting must be threshed by other means, since the grains must be separated from a relatively large amount of straw. Usually a threshing machine is used to increase efficiency.

Grain damage can be caused not only by delayed harvesting but also by improper handling subsequent to harvesting. The over-dried grains are prone to fracture during threshing, whereas moist grains are likely to bruise through improper cylinder-concave clearance and high thresher cylinder speed. If not carried out properly, harvesting and threshing by machines can be more injurious to seeds than manual methods. Of course, threshing by beating with sticks can crack or break the grains into pieces and should be discouraged as a means of seed production.

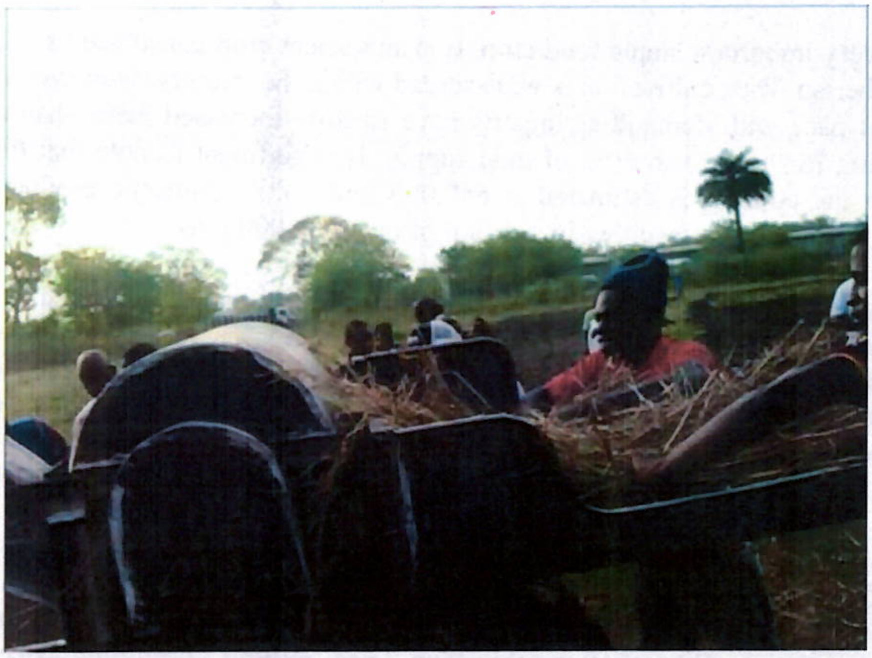

Fig.4. A Mobile Threshing Machine in operation

It is very important that rice processors maintain good business relations with rice farmers in addition to providing continuous extension services. This will ensure that the critical timeliness required in the pre and immediate post harvest operations are properly handled. It will also be beneficial to provide support facilities such as harvesters, mobile threshers and winnowers. The company could lease such out to farmers' cooperatives or operate it themselves in a contract buying scheme. This will ensure that the quality of the paddies destined for the processing factory is good enough for a satisfactory finished product. Where such arrangements are already in place, it is important that they are maintained in such a way that there is mutual protection of the interest of the stakeholders to ensure sustainability.

SECTION 2

BASIC BUSINESS ENTERPRISE OPPORTUNITIES DEVELOPMENT IN THE RICE VALUE CHAIN

Globally, rice is a very important staple food crop. It is an ancient crop consumed as staple food by almost every Liberian. Rice cultivation is wide spread within the country. However, domestic supply has not kept pace with demand as imports have steadily increased faster than domestic supply by accounting for more than 60% of total supply. It is pertinent to note that the annual demand for rice in the country is estimated at 650,000 tons, while domestic production is at about240,000 tons of milled rice resulting in a deficit of over 400,000 tons.

Liberia has the potential to increase her domestic share of the rice market in a medium to long term investment strategy that can develop into a self- sufficient industry locally. More so demand for rice will be sustained in Liberia as rice remained the most popular staple food for the people. Besides the demand from households, which keep rising, there is increase due to increase in restaurants and steady growth in urbanization. On these bases, there will be business opportunities in typical rice processing environment although they are associated with challenges.

2.01 Business Opportunities and Challenges in Rice Processing

A lot of business opportunities abound in rice processing outfit. These include rice farm input supplies, paddy farming, paddy trading, threshing, rice milling, destoning, rice trading, packaging, and haulage (transporting). These sectors of business enterprises are interconnected and diagrammatically represented as follows:

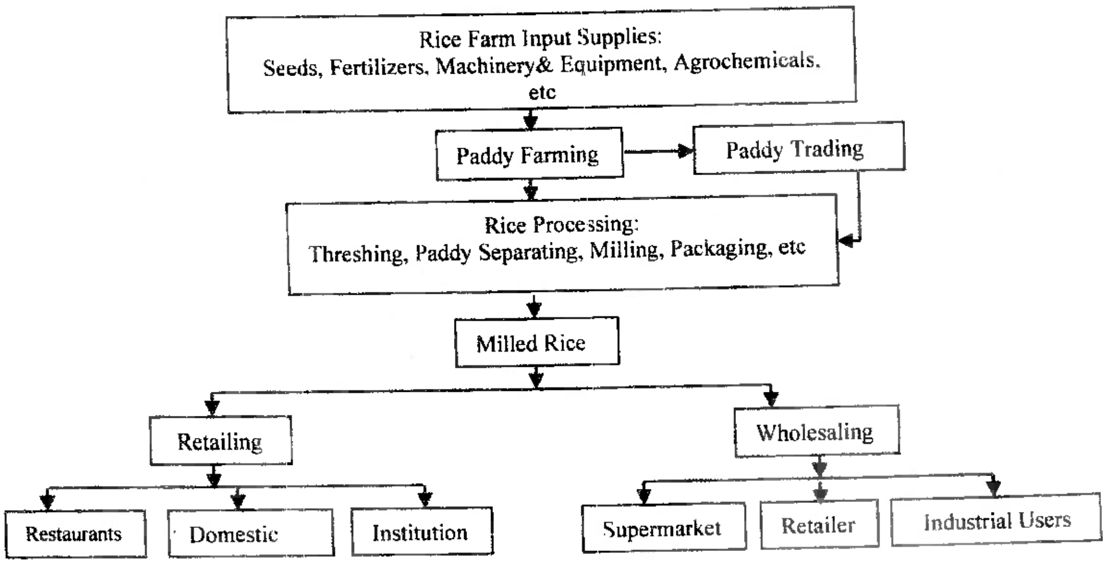

Figure 5: Flow Chart for Business Opportunities in Rice Industry

2.02 Rice farm input supplies

Successful rice farming hinges on supply of right inputs at the right time in the proper amount. These inputs include agrochemicals, rice seeds, fertilizers, spare parts of various agricultural machines, etc. Establishment of rice input supplies stores in rice producing areas and providing the needed services associated with the use of the inputs standout as lucrative business ventures. An example of such associated services is agrochemicals spraying services which can be carried out on contract bases to farmers. Rice production is known for being strenuous and labour intensive, and with the era of labour shortage setting up of equipment hiring outfits in rice producing communities for small, medium and even large-scale farmers to hire will be a very profitable area of investment for investors. The machines include threshers, tractors, harvesters; etc will reduce drudgery in paddy production and expand farmers areas of cultivation. Other inputs include packaging sacks, tools, simple laboratory testing equipment and consumables etc.

2.03 Paddy farming

Paddy farming is a very profitable enterprise although associated with high risk and uncertainty. It therefore calls for the farmer having a sound agronomic knowledge in rice cultivation. This agronomic knowledge can be acquired through trainings which can be organized by CARI and AfricaRice and by reading of rice cultivation literatures. Rice farmers that have good knowledge of rice agronomy can engage on pure rice seeds production that serves as input to farmers for mass production since improved quality rice seeds remains a serious problem in local rice industry. Paddy farmers also produce paddy and sell to processors or paddy traders at high profit margins. This makes paddy farming a sustainable business.

2.04 Paddy Trading

Paddy trading is a lucrative area in rice industry. Paddy traders purchase their paddy directly from farmers during the harvest period at relatively cheap farm-gate prices. They however, add values to the paddy by drying to preserve the grains at low moisture content and store in their facilities. The paddy traders then sell to processors during off season at high profit margins despite the costs of adding value to the paddy. At times they mill their paddy and sell thereby maximizing their profits.

2.05 Rice processing

Rice processing involves various stages that range from threshing to packaging. There are medium size machines that carry out these various stages of rice processing like threshers, de-stoners, milling and packaging machines, etc. Investors can invest on establishing such different components of processing in rice producing communities that will be servicing the small, medium and large- scale rice producers. Large volumes of paddy can also be milled in an integrated rice mill plant.

2.06 Rice trading

Trading in milled rice is one of the important links in the rice value chain. Production of any product is incomplete until it gets to end users. Therefore rice trading occupies a prominent place in rice value chain. Rice trading enterprises are involved in wholesaling and retailing. Rice wholesale operations involve sales of rice to retailers, other rice wholesalers, industrial users, supermarkets and to lesser extent, the ultimate consumers. The rice wholesalers may buy from farmers or processors and sell to rice retailers. They are responsible for geographic distribution of rice. While retailers sell to ultimate consumers, restaurants and supermarkets. Rice haulage (transporting) is very essential area of business opportunity in any rice trading since both the paddy and milled rice must get to points where they are needed.

In all these business opportunities in rice processing there are lots challenges. These are constraints within rice sub-sector. They are factors in the immediate business environment but having implications for performance and outcomes of the business investors. These challenges are:

- At the farm level, constraints include methods of production, scarcity of labour, scarcity and high costs of inputs.
- There is a huge market for the locally produced rice hence there is a potentially high demand for quality rice seeds. Presently there is serious supply-demand gap. For improved rice seeds.
- There is poor state of infrastructure especially roads and power (electricity). The farms are not serviced by good roads or electricity.
- There is problem of sourcing labour to work on the farms. Youths who are key labour providers have gone into motorcycle and tricycle transport business which offers them quick money than strenuous labour in rice farms. The male out-migration to cities in search of better paid jobs also affects labour availability in rice industry.
- The alternative to manual labour, which is mechanization, is expensive and most rice farmers cannot afford it on their farms. This makes it difficult to be involved in the production of large hectares of rice.
- There are challenges in areas of machinery importation. The cost of importing such equipment for sale is quite prohibitive. The government policies on rice importation may not present the best response for attracting investments into the local rice industry. They may fail to provide sufficient incentive for investments.
- The costs of inputs such as fertilizers, improved seed and agrochemicals that enhance productivity might be high without subsidy. This impose limiting effects on the extent farmers can expand their farms. It is therefore necessary for government and processors to support farmers if they expect improve the supply of local rice paddy from them.
- A good business opportunity exists in the design and production of suitable packaging materials for high quality rice products.

2.07 Business Structures or Organizations

Having identified a lot of business opportunities in rice processing sub- sector, although associated with challenges that are surmountable, there is need to consider adoptable business structures or organizations in establishing enterprises in any of the existing business opportunities in rice industry. It is important to note that the type of business structure practiced has a large effect on enterprise. Amount of capital available also influences decision on business structure to adopt. Therefore it varies with scale and nature of operations. Based on these there are different main forms of business structures or organizations namely: single proprietorships, Partnerships, cooperative and corporation (company).

2.08 Paddy Sourcing

Rice paddy is a raw material for any rice processing outfit. Sourcing of rice paddy therefore becomes very paramount. Rice cultivation is spread over five ecologies, namely: rain fed upland, rain fed lowland or shallow swamp, irrigated rice, deepwater or floating rice and tidal mangrove swamp, in the country.

Many large, medium and small-scale rice mills source their entire rice paddy from farmers. While in some cases rice processing firms might develop their own farms. Processors can also involve in paddy out growers schemes with such out growers serving as sources of paddy to them. In the out growers schemes the processors will provide the farmers with seeds of improved varieties of rice varieties and other necessary inputs, and also pre-determine price for the paddy they will produce for the season. Contract farming is another viable option of securing paddy. Contract farming is where a processor or other buyer provides inputs on credit (in cash or kind), linked to a purchase agreement. Repayment of the initial input credit is deducted when the farmer sells the produce. Contract farming and out growers schemes reduce the risk of side-selling to other producers by building formal contractual relationships with the farmers.

2.09 Criteria for Purchasing Paddy in the Fields/ Markets

In purchasing paddy in the fields or markets there are quality attributes of the paddy that are normally considered pertinent and are also based on processors and consumers preferences. These criteria serve as market value or price determinants and for grading of paddy. These quality attributes are discussed below:

2.10 Percentage foreign matter content: The foreign matters include chaff, stones, weed seeds, soil particles, rice straws, etc which come from the field or drying floor. The presence of these foreign matters directly influence the quality of the paddy or milled rice as article of commerce which results to low market or farm-gate price.

2.11Purity of paddy variety: Paddy with mixture of varieties commands low price due to difficulties it causes in processing during parboiling and milling which usually results into reduced milling performanc, excessive damage, lower milled rice recovery and reduced head yield. Lack of product uniformity therefore means that cooking times and results vary which adversely affects consumers' preference.

2.12 Percentage content of immature grain in paddy: This negatively affects the market value of any paddy since such paddy results in excessive bran, broken grain and brewer's rice during processing.

2.13 Moisture content of the paddy: Preferable Paddy moisture content which gives optimum milling potential is 12% to 14%. Paddy moisture has a very significant influence on paddy quality. High moisture content causes paddy to grow moulds leading to discolouration and objectionable odour after milling of the paddy. Hence paddy with high moisture content tends to have poor preservation quality and commands low market value.

2.14 Discolourations of paddy: This is an indication of high moisture content, insects and microbial infections and exposure to heat which caused the paddy to deteriorate through biochemical reactions in the grain that result in the development of off odour and changes in physical colour appearance. Discolouration causes low market value of paddy.

2.15 Aroma and swelling capacity of the paddy: Rice with these qualities commands high consumer preference by consumers of all income classes because it has consumers' preferred distinct taste. However these qualities are function of traits associated with specific rice varieties.

2.16 Freshness of paddy: This criterion weighs heavily in the purchasing behaviour of consumers. Therefore, it should be accorded high emphasis in terms of considering which paddy to be purchased.

2.17 Starch content and length of grain: Long grain parbioled rice with intermediate level of starch is becoming the preferred milled rice by most consumers in Liberians especially in urban and peri- urban areas. These criteria should serve as guide for the purchasers of paddy in the fields or markets and paddy producers as to realize their set business objectives.

2.18 Matrix of Best Characteristics of Quality Paddy:

Characteristics of paddy mean a lot to rice processors, marketers and consumers. The following characteristics serve as the most standard guide for determining best quality paddy, hence the price determinants:

- ❖ Volume grain weight;
- ❖ The percent of whole grain;
- ❖ Grain moisture content;
- ❖ Traits, substantiality, hardness of grain, and uniformity in size; and
- ❖ Palatability and preservability.

These characteristics are important quality indicators of best paddy which are explained in detail in table1.

Table 2: Quality parameters for Best Paddy

No.	Characteristics	Descriptions
1.	Volume grain weight	Well dried grains show high volume weight. It is considered as index of rice substantiality. High volume weight rice, in general, shows superior milling ratio and preservability.
2.	Percent of whole grain	Whole grain percentage deals with rice substantiality from its appearance. It is measured in terms of specific gravity several of types of rice. Whole grain has highest specific gravity followed by white belly rice, white core rice, malformed rice and dead rice. However this classification is associated with ripening condition.
3.	Grain moisture content	Moisture is laid stress from view point of preservation rather than a weight decrease cause by evaporation. Grain moisture content influences all aspects of paddy quality significantly. To obtain high milling

recovery ratio it is necessary to mill at 12% to 14% moisture.

4. Percent of foreign matters	Foreign matters in this context include straw, weed seeds, stones, chaff, etc. They often result from the fields or drying floors. Foreign matters directly influence the quality of paddy as article of commerce. Paddy with minimal percent of impurity is classified as superior paddy.
5. Percent of discolouration	Cause of coloured rice is damage in its endosperm owing to microorganism such as moulds and bacilli. Along with this, insect injury by white tip can be incitement. Even after milling coloured rice retains some spots on it, which therefore necessitates crucial criteria of inspection. The third class rice allows 0.001% of coloured rice that is 1 coloured grain out of 1,000 grains, while the fifth class rice allows 0.1% of coloured rice.
6. Trait purity	Paddy field planted with different varieties of rice leads to production of paddy with mixture of grains of different traits. Such paddy present difficulties in processing and should be avoided.
7. Palatability	The following are greatest common factors for best paddy considered to be palatable rice: the colour is white or glossy; suitable in figure; taste does not change while masticating; unaccountable sweetness of starch; grains are to be soft, but are to give slight resistance to the teeth; viscidity and hardness.
8. Percent of immature grains	Immature grains occur as a result of differences in seedlings planting dates in the same field. The prevailing weather condition at ripening stage also causes such. Therefore timing of planting in the nursery and transplanting into the field is very crucial as to reduce the percentage of immature grains in the paddy. Immature rice kernels are very slender and chalky that result in production of excessive bran, broken grains and brewer's rice during milling hence efforts should be made to procure or produce paddy with less than 0.1% immature grains.
9. Uniformity in grains size	Paddy with uniform size is an indication of varietal purity and has advantages in terms of high milling recovery and less broken rice. It gives better uniform cooking time and result which augur well with consumers' preference.

10. Percent of starch content	Quality of starch is an important factor from the view of palatability and fundamental traits. Starch types found in rice consists of amylose and amylopectin. The ratio of amylose to amylopectin determines the quality characteristics such as palatability. Although this perception by consumers varies for people from different parts of the world and the different ways rice dishes is prepared.

2.19 Importance of Buying Agents in Quality Paddy Sourcing

Buying agents play vital roles in agricultural products marketing which Paddy is one of the major products. These buying agents can be grouped into commissioned and non-commissioned agents. Commissioned agents buy and sell products for the principals and receive commission on the turn over. While non-commissioned agents operate on a contractual basis, by arranging transactions between buyers and sellers, thereby making some margin of profits of such transactions. The end –user specifies the quality requirements of the paddy such as percentage of insect damage, weather damage and foreign matter content. The price for the paddy to buying agent is based on market information but will usually cover the market price of the paddy, market charges, transport to aggregation centre, handling charges at the farms or centres and a premium. Paddy purchases usually intensify during the harvest season.

The roles of buying agents in quality paddy sourcing are very pertinent. Most of the buying agents are experienced in paddy sourcing which agribusiness firms needed to utilize optimally. They know the best quality paddy that fits into market value chain and are conversant with paddy market environment. Buying agents are much acquainted with paddy producers and they know areas where paddy can be sourced and purchased at very acceptable prices at the various times of the year.

Most paddy producers in Liberia operate at cottage and small scale hence the buying agents will be needed to do the aggregation or assembling function by buying and bringing together of small lots of paddy from different farms or markets to form bulk. They will add value to the paddy by ensuring that quality paddy gets to where it is needed and at the acceptable quality and conditions prescribed by the processing firms and other end users.

Besides using of buying agents in sourcing quality paddy transfers the risks associated with purchasing poor quality paddy to buying agents. That is, in the event of purchasing poor quality paddy the purchaser or the buying agent bears the responsibility in terms of incurring the losses involved. In words, the principal or the firm that is ordering rejects the poor quality paddy without incurring any loss.

Although there are a lot of advantages in the use of buying agents in sourcing paddy, it is important their tendency to shortchange other value chain actors is curtailed by monitoring and dissemination of market information.

2.2Q Building a Collaborative Relationship with the Rice Farmers-Promoting Trust and Sustainability

Rice farmers are vulnerable to a lot of risks and uncertainties. In rice farming business, although lucrative, economic and biological risks are involved. Besides, most small-scale farmers are poor as to handle these embedded problems in farming business that weaken their trustworthiness ability and continued sustainability in their farming business. It is therefore necessary for processors and rice traders to establish collaborative relationship with rice farmers as to promote trust and sustainability. This can be realized as follows:

(i) Contract farming

In contract farming the rice processor or rice trader provides the inputs on credit to rice farmer which may be in cash or kind, linked to a purchase agreement. Repayment of the initial input credit is deducted when the rice farmer sells the produce. This reduces the risk of side- selling to other producers or processors or traders by building formal contractual relationship with the farmer. This will lead to developing strong processor or trader- farmer trust.

(ii) Out grower schemes

Another way of building collaborative relationship with rice farmers that can promote trust and sustainability is rice processors or traders establishing out growers schemes for rice farmers. Out growers schemes are a more integrated form of contract farming, whereby the rice processor or the trader has greater control over smallholder production. Smallholder rice producers basically offer their land and labour in return for a package of inputs and extension services. In other words the processor or the trader works closely with those rice growers, providing financing, technical assistance in production, post-harvest handling and packing materials. In return, the farmers sign contracts guaranteeing to sell to the processor or the trader. The contract specifies the production calendar, the volume required and the quality of the produce.

(iii) Producers associations linked to processors and buyers

Rice producers associations can be formed and linked to processors or rice traders. The association sizes should range from 20 to 40 members. This linkage assures the farmers of market for their products. The associations can be promoted and stimulated by linked processors and buyers through payment of certain percentage of premium on their paddy prices.

(iv) Rice farmers cooperative

The rice farmers should come together and form rice producers cooperative. The farmers pool their resource together thereby making bulk purchase of inputs like fertilizers, agrochemicals, etc which enable them to enjoy the advantages accrue from economy of scale. After harvest marketing of their paddy can be collectively done which will reduce their marketing costs. With these relationship arrangements the farmers' trust and sustainability will be highly promoted.

SECTION 3

POST-HARVEST HANDLING OF PADDIES

3.01 Principles of Winnowing/Cleaning of Paddies.

After the threshing operation the paddies are mixed with a lot of straw, leaves, husk etc. It is possible to separate these contaminants from the clean whole paddy. Most of the lighter contaminants are removed by winnowing. In the manual operation of winnowing the paddy mixed with these materials are poured from a height into a container below (Fig.7) and the lighter materials are blown out by the wind. This process can be repeated several times until the paddy is fairly clean. The manual process has a number of disadvantages such as dependence on weather and difficulty of control. Besides whenever there is much harvest, it means that lots of extra work and labour will be required.

Fig.6 Manual Winnowing

However this process can also be mechanized. Mechanical cleaners use forced convection air from electric or motorized fans that generate wind current while the paddies pass through a number of reciprocating screens. In the process lighter materials that are less dense than the paddy are blown out and removed. Other contaminants of comparable or of higher density are screened by the sieves which sort them out according to their sizes. It is best to ensure that threshing and cleaning are done at the farm before the paddy is delivered to the rice mill. Improperly cleaned paddy can adversely affect the storage and quality of products. Paddy and rice with impurities are more likely to deteriorate during storage. Contaminants will also reduce the milling efficiency and impose an avoidable load and wear on machinery especially if there are stones mixed with rice. Unclean paddy increases the maintenance requirement on milling machines and downtime.

3.02 Paddy Storage Structures/Conditions for Dried Paddies.

The moisture content at harvest could be as high as 20-26%. If the grain has to be stored for an extended period, it must be dried either in the sun or in a mechanical dryer utilizing heated air. If the harvesting is done under the sun, then a rainy and humid weather with high moisture content could be a problem. Mechanical drying is the best option for rapid drying of paddy. Before milling and storage, rice must be dried thoroughly. Rice which is not dried properly may crack during milling, or spoil during storage. The moisture content of paddy must be reduced to about12-14% before milling or storage can safely occur. Farm based preliminary drying operations should be encouraged where possible. The alternative is to ensure that paddy which arrive the mill at high moisture content is quickly dried to a safe moisture level. This will become more serious whenever there is increase in the supply of paddy resulting in prolonged storage.

When the moisture content is above 14% there is the risk of infective mold growth. The effects of mold growth on the paddy include production of off odours and off taste in the rice. In addition hydrolytic enzymes and toxins are produced. These will impart objectionable quality on the product. Famers should also be encouraged to have silos where dried paddy can be stored until they are needed. Fig. 7 and 8 show suitable designs that could be used at the farm level. The silos could even be designed to have an in-built drying facility to ensure moisture content does not increase during storage. They must be of rigid structures even plastic tanks and barrels could be used. All storage structures must be capable of protecting the grain from entry of rodents and insects as well as prevent the entry of moisture. Processors and Paddy Aggregation Centres (PACs) should only buy from farmers whose paddy meet the relevant specifications or surcharge those that supply paddy that requires extra cleaning. The farmers should be encouraged to be capable of managing preliminary post harvest operations such as threshing, cleaning and drying, with minimal support.

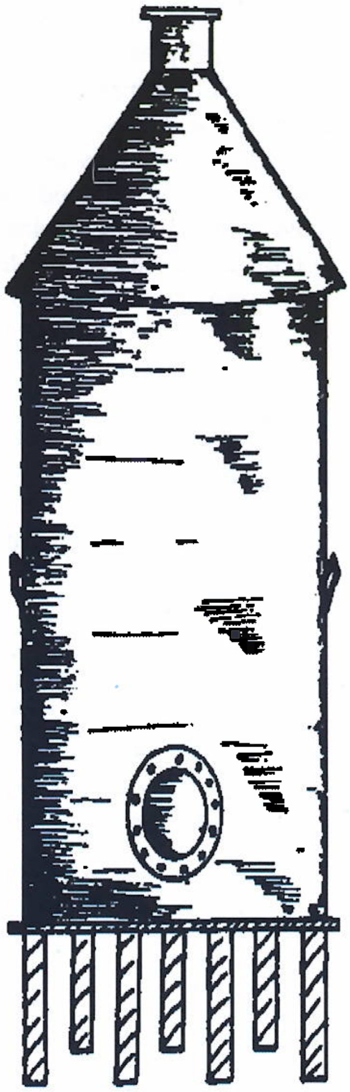

Fig.7. A Suitable Farm- Based Silo Made of Steel.

Fig. 8 A Typical Rural Farm-Based Attic Storage

When paddies are being kept for long term storage, it is important that appropriate preservatives are applied. This is important for prevention of infestation by weevils and other pests that could damage the grains and impair quality. Presently the use a pesticide and a rodenticide should be sufficient to safeguard against grain damage when combind to moisture control. However the storage of most of the paddy in silos would ensure that less of these chemicals are released into the atmosphere. Management must ensure that adequate safety measures are observed in the application of these chemicals. It could be beneficial to alternately use other suitable chemicals with the present ones to avoid the development of resistance by the target organisms. Figs. 10 and 11 show some of the common weevils that could be found in rice. Some of these enter the rice in the field and continue to proliferate until storage. Sometimes it is the eggs that are laid on the grains which eventually hatch and cause havoc during storage if allowed unchecked.

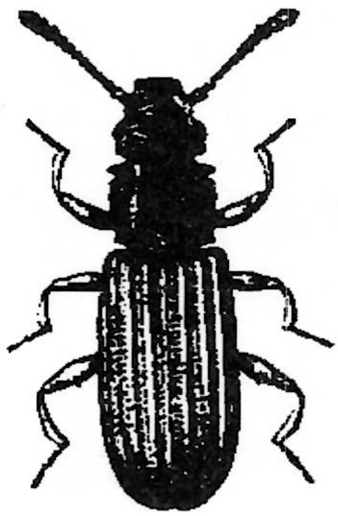

Fig.9 *Cryptolestes ferrugineus* (rust-red grain beetle)

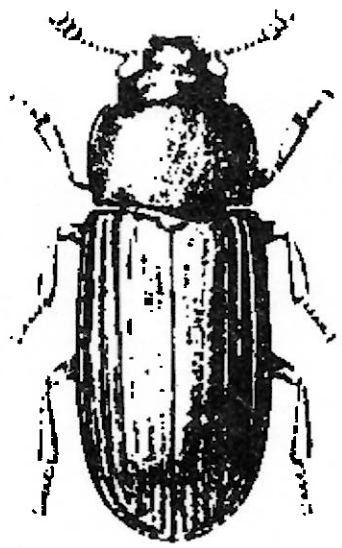

Fig.10 *Rhyzopertha dominica* (lesser grain borer)

In cases where threshed and dried rice is packed in bags and stored on wooden pallets in a storage facility, the bags should be stacked to allow good ventilation, since free air movement between the bags will prevent mildew and/or spoilage. Do not allow the bags to come into direct contact with the floor or walls, since moisture tends to condense where there is contact. Such storage should not be for too long. If rats are a threat apply fumigation, set rat traps (or get a cat!). Check the rice periodically for signs of spoilage and/or pest infestation.

When paddy is stored for a long time it is important that their quality parameters are evaluated periodically. Rice processors should always be careful when they procure paddies for processing. Apart from laboratory analysis the following tips for physical inspection can be useful for selecting paddies for processing:

- Dampness- the paddy should feel dry and flow easily
- Colour brightness- should have a light yellow straw colour and of uniform appearance. Green, gray and brown tips are not good
- Husk properties- the husk should neither be too thin nor too thick
- Good paddy should be as free as possible from foreign matter and impurities
- Presence of damaged corns- should be as low as possible
- Corn shape should be regular and the size acceptable

- The appearance should be as uniform as possible
- Presence of pests – should be minimal

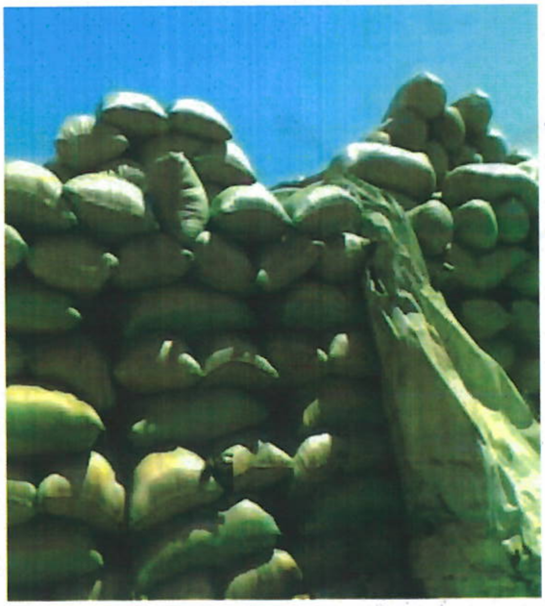

Fig. 11 Improvised Paddy Storage

Fig. 12 Improper Storage of Paddy in the Open

Fig.13. Modern Rice Storage Silos at a Rural Location

3.03 Raw Materials/ Paddy Quality Assessment / Parameters

The two major raw materials in production of parboiled rice are:
1. Paddy rice
2. Water

The water is mostly used for heating the rice during parboiling. It could be used as steam or boiling water. Some of the water is absorbed by the hydrating starch, protein and other constituents of the grain thus becoming part of the grain. Some of the most regular tests done on rice paddy are described below:

Assessment Parameters

1. **Moisture Content Determination:** Grain moisture should always be calculated on a wet weight basis. In other words, 100kg of 15% moisture contains 15kg of water and 85kg of dry matter. There are several ways of measuring grain moisture, some of which can be easily done on the farm with very little equipment.

- **Salt and bottle Method:** this quick and easy method is accurate to within 0.5% but will only indicate the grain is above or below 15%. the maximum limit for storing rice paddy in sack bags.

Thoroughly dry out a bottle 100ml capacity and full it three quarters full with rice paddy. Add 5-10 teaspoon of oven dry table salt, seal the bottle with a dry lid or cork, and shake for several minutes. If the salt sticks to the inside of the bottle the grains has 15% moisture or more.

- **<u>Oven Method</u>**: A grain sample of known weight should be oven dried for one or two hours at 130^{O}C if ground or 72-96 hours at 100^{O}C if in whole form. After reweighing moisture content can be calculated as follows:

%moisture content of original sample =

$$\frac{\text{Wet weight} - \text{Dry weight}}{\text{Wet weight}} \times 100$$

How to estimate the final weight of grain after drying

Final grain weight after drying

$$= \frac{\text{\% dry matter before drying}}{\text{\% dry matter after drying}}$$

Example: A farmer has 200kg of paddy rice at 20% moisture. How much will this amount of paddy weigh after it has been dried down to 14% moisture.

Final grain weight after drying $= \frac{80\%}{86\%} \times \frac{2000\text{kg}}{1} = 1860$kg of grain after drying to 14%.

- **<u>Grain moisture meter</u>**. The use of moisture meter is for monitoring paddy and milled rice moisture content. The quality specification for raw paddy are shown in Table 1.

2. **Varietal Purity:**

There are two methods for testing the varietal purity of paddy.

- Measuring grain dimension using venier calipers and comparing the length / width ratio of grains to the published ratio for the variety.

- Measuring the 1000 grain weight of paddy and comparing the results to the published 1000 grain weight for the variety

If the length /width ratio and the 1000 grain weight differ from the published figures for the variety, then the sample is impure (containing either a different variety or a mixture of varieties).

3. **Percentage Cracked Grains:**

Cracked grains are the single largest contributor to rice breakage during milling, which reduces head rice yield.

- Procedure: Randomly obtain a sample of paddy large enough to provide 100 grains. Using a crack detector or magnifying glass, count the number of racked grains in the sample batch, calculate the % cracked grains

$$= \frac{\text{No of cracked grains}}{\text{No of grains originally}}$$

4. **Percent Discoloured Grains:**
   - Procedure: from a randomly selected sample, weigh 25g sample. Select and separate the discolored or yellow fermented grains from the sample. Weigh the discoloured grains separated from the sample. Calculate the % discoloured as

     $$= \frac{\text{Wt of discoloured}}{\text{Wt of sample}}$$

5. **Percent Dockage:**
   - Procedure: Randomly select and weigh 100g samples. Sort all foreign matter, stones, weed seeds, husks. Weigh the sorted foreign matter and compute the total dockage percentage as follows:

     $$\%\text{Dockage} = \frac{\text{wt of dockage}}{\text{total wt of sample}}$$

6. **Percent Immature:**
   - Procedure; Randomly select and weight 25g sample. Select and separate the immature grains from the sample. The immature rice grains are those that are very slender and chalky. Weigh the immature grains and compute their percentage as follows;

     $$\%\text{immature grains} = \frac{\text{wt of immature grains}}{\text{total wt of sample}}$$

Other aspects of rice quality paddy are presented in sections 1.5, 2.2 and 5.1. Some parameters of the process water are presented in section 3.3.

3.04 Concept of Product Coding and Traceability

Food product tracing is critical at all levels of the food system to protect public health by isolating products early to help in managing a food safety incident. The safety of the food supply requires a comprehensive and coordinated effort among all stakeholders throughout the supply chain from farm to fork. Effective product tracing would improve the efficiency and speed of response time to a food safety triggering event and would greatly contribute to the protection of the public health and maintain consumer confidence following such an incident. The provisions of international and local regulations have to undergo regular reviews to ensure that the safety of consumer can be optimally protected and that the impact of deliberate or accidental contamination of food products and commodities can be reduced as much as possible.

For any product to be traceable it has to be properly coded. The coding must take into account the complexity of the supply chain. The product or its ingredients from which it is made and their sources should be properly captured by the coding system. A food product may contain several active ingredients that may have been handled, processed, stored and distributed by hundreds of stakeholder along the supply chain. With the aid of the coding system a number of safety measures can be implemented. These include:

1. Fast identification of the initial point of occurrence such as the originating point of a contamination
2. Rapid investigation and evaluation of the spread and impact of an objectionable product.
3. Easy recall of unsafe products that have already gone into the supply chain.

The coding and supply systems must be regularly monitored and updated to take care of changing trends and new developments. The code applied to a product must capture as much information as possible to enable traceability of the product. The codes may be manual or electronic. Coding systems may be developed from simple labels, bar codes, encryptions, tracking devices, microscopic implants etc.

In the rice processing business it is important the sources of the major ingredients especially the paddy are properly documented and remain traceable. It should be possible to trace the farms, paddy aggregation centres and suppliers from where paddy is sourced to fill a silo. The vehicles and drivers involved in the transportation should be known and properly recorded. The records of the entire processing system should be properly kept and this should cover timing of the process, the personnel and shifts involved, the quality control checks, the timing and movement during warehousing. Records should also be properly kept of the distribution channels from wholesalers and retailers and possibly to the final consumer. The entire chain should be traceable and monitored regularly. The processor should utilize the coding and traceability concepts to investigate consumer complaints and possibly respond to the feedback information obtained.

SECTION 4

RICE PARBOILING TECHNOLOGY

4.01 Concept of Value Addition

Processing of rice paddy into a variety of products creates a system of value addition. Value-added refers to the difference in the cost of buying raw materials including the cost of other inputs and the price at which it is offered for sale. Value is added to rice by processing it in a mill into parboiled and/or unparboiled rice for the market it serves. The process confers on rice some unique advantages over the unparboiled product. Similarly, more value can be added to rice and rice products by development of new products even by improvement of already existing ones. For example breakfast cereals like rice cripses, ricevita, rice flour, fortified rice, rice grits, adhesives and even alcoholic beverages are all made from rice.

The entire chain develops from the rice farm through the paddy supply system and the milling processing to consumption. At each level the product acquires a higher value by being transformed, preserved, packaged, stored and presented for purchase or use. Every member of the value chain profits for the effort of adding value to the product. The ordinarily raw produce which is of little value is converted to a product that is readily sought after and consumed by its users. The stakeholders along the value chain try to adjust to the predictable demand in order to improve their earnings. For example the farmers are made to grow the varieties that will give the best results in terms of yield and overall earnings. The processors must also continue to modify their processing systems to produce higher quality products that attract improved consumer acceptance and demand. As the rice business continues to develop from the farm to the final consumer, more investors will find the opportunity to invest and earn the added value to the commodities. Some investors buy poorly processed rice and add value to it by further processing it using more modern equipment to clean it, grade it and for example making it "stone free" in addition to packaging it in more attractive packages. The product simply becomes higher valued and attracts higher prices.

4.02 New Technologies in Soaking of Rice/ Other Operations

Rice milling technology has evolved over a long time and present practices must have been the result of improvements in ancient practices. Modern rice milling technology is largely customer driven and there is an unending quest to produce a variety of high quality products that satisfy diverse consumers' desires. A major development in the rice processing technology is the introduction of the parboiling process. Parboiled rice eventually became an international commodity with widespread appeal. The parboiling process involves soaking of the grains and boiling in water but the modern improvements of this process involves the application of steam during the process. The difference between the two types will be discussed later. Modern equipment for rice processing is discussed in section 4.

Parboiling is a hydrothermic process that involves a time/temperature/moisture treatment. It causes the moderate transformation of the kernel components. The major advantages of parboiling of paddy rice are as follows:

- It can improve the milling qualities of paddy. The husk softens and cracks during parboiling, making it easier to mill. It is well known that parboiling reduces breakage during milling. The cracks in the grain are "melted" together, leaving fewer broken grains and resulting in reduced loss during milling. This improvement is usually attributed to increased hardness, or the healing of sun-cracks and other defects resulting from biochemical changes. The percentage of broken is drastically reduced and the head rice yield is remarkably increased, as shown in Table 1. Parboiling leads to an increase in total yield as well as head yield (yield of full size rice).

Table 3. Head and Total Yields or Raw and Parboiled Rice of Mixed Varieties

Type of rice	Total yield (%)	Head yield (%)	Remarks
Raw	71.3	52.1	Modern mill of the Dandekar
Parboiled	73.0	53.9	type was used for milling.

Source: Mathrani, 1971

- The rice grain is composed of a surface layer called bran (itself consisting of the pericarp and aleurone layers), the starchy endosperm, and the germ. The surface layers are rich in protein, oils, and vitamins compared to the endosperm. Parboiling improves the nutritive value of rice products by the translocation of vitamins from the peripheral layers to the central core, and oil from the endosperm to the bran layers. Several of the thin protein layers underlying the husk are boiled into the endosperm, thus increasing the protein content of the kernel, followed by heat sealing them.

Table 4: Nutritional Properties of Two Types of Milled Rice -White (Raw/ Non-Parboiled) and Parboiled

Rice type	Crude protein (%Nx6.25)	Lysine (g/16%N	Balance data in five growing rats			
			True digestibility (% of N intake	Biological value (% of digested N	Net protein utilization (% of N intake)	Digestible energy % of intake
1R480-5-9 Raw	11.2	3.4	100.4	66.8	67.1	97.0
Parboiled 10min	10.4	3.6	94.7	70.4	66.7	

IR8 Raw	7.7	3.6	96.2	73.1	70.3	96.6
Parboiled 20 min	7.2	3.7	89.7	78.1	70.0	95.2
Parboiled 60 min	7.4	3.5	88.6	79.5	70.4	94.7
LSD (5%)	0.2	0.2	0.9	1.1	1.4	0.5

Source: Juliana 1993- Rice in human Nutrition

- Bran from parboiled rice contains less starch and more oil than white rice bran. The oil content of parboiled bran varies from 15 to 25 per cent, about 5 per cent higher than in raw bran.
- The cooking quality of rice may be defined as the ability of the grain to be cooked to the required texture or tenderness without losing shape. A grain that cooks to a fluffy, non-cohesive, tender texture, and retains its shape, while increasing in size, is said to have good cooking quality. Although may vary in different countries.
- Par-boiling improves storage quality of the grain. The grain's tendency to absorb moisture from the air decreases, so that par-boiled rice keeps longer in storage.

But parboiling also has disadvantages:

- Parboiling is labor-intensive
- Parboiling alters the appearance, sight, smell, taste, and texture of the rice and generally decreases its eating quality in areas where white rice is cultural.
- Parboiled rice is harder and therefore takes longer to hydrate and cook.
- The heat treatment during parboiling destroys some natural anti-oxidants; hence rancidity developed in parboiled rice during storage is more than that in raw rice.
- Parboiled rice may have characteristic off-flavour which may not be liked by white rice eaters.
- Parboiling process needs extra capital investment
- Parboiling adds to the cost of drying
- As paddy is soaked for a longer time during parboiling, it may be attacked by spores which may constitute health hazard.
- More power is required for polishing of parboiled rice. The process becomes difficult and lowers the capacity of polisher.

When it comes to the question of whether to parboil or not, there is no such thing as a "recommended" practice. Depending on the circumstances especially the market, par-boiling may or may not be economical and/or desirable. Also if grain losses during milling, protein content, or storage quality are important to the processor, par-boiling may be preferred. If labour considerations, eating quality, or cooking time are important, the rice may best be processed into white (non-parboiled) rice.

4.03 Latest Information/Technology in Parboiling of Rice

New technology for soaking and parboiling of rice (Fig. 15) include the three steps of **hot-soaking, steaming, and drying**. However this procedure is not very strict because different modern processors can adapt slight modifications to achieve their peculiar aims and objectives. For example it may be necessary to start with a steaming step before soaking which among other advantages reduces the microbial load that could have produced odours during soaking. The steaming process in some plants could be repeated after the soaking process. It is known that weight losses results during parboiling and drying. This varied from 0.85 to 1.75 per cent of the total input. The lowest percentage losses were observed with the modern parboiling methods in which hot soaking of paddy is completed in less than four hours.

Fig. 14 Modern Rice Soaking Tanks

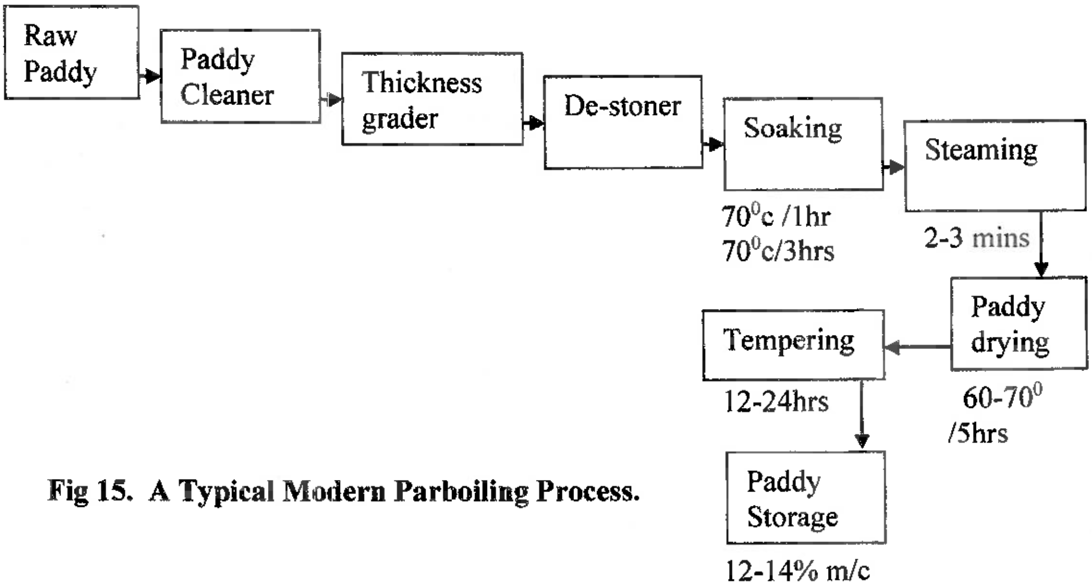

Fig 15. A Typical Modern Parboiling Process.

4.04 Hot Water Parboiling and Steam Parboiling Systems

The parboiling process is a major factor in the production of good quality parboiled rice. Therefore it must be carefully carried out irrespective of the method used. Most cottage scale rice millers use the hot water (soaking) method. However the use of steaming process could be applied by both the small and modern integrated rice mills. The hot water method involves cooking the paddy rice in water. The paddy may be allowed to steep in hot water for varying duration. The steaming process involves the application of steam to the paddy to cook it. Some processors use a combination of both processes with two hot water processes interspaced by a steaming process. Different rice millers have adopted slight modifications of the process to serve their needs. The major objective is to achieve a uniform modification of rice macromolecules and make the rice more functional in terms of subsequent milling operations. However it must be noted that the traditional method often leads to poor quality products. Some of the problems associated with this method include:

- Difficulty of control of process
- Lack uniformity of treatment of products
- Difficulty of handling large quantities at a time
- Non-uniform water and temperature treatment.
- Leaching of essential nutrient resulting from long soaking time (Fig. 15).
- Steaming time is not controlled but depends on observed splitting of grains
- Excessive heating may occur and cause discolouration of rice grains
- Different varieties are subjected to the same condition of soaking and steaming.
- More chalky grains are produced when not carried out by skilled personnel.
- Odour development may occur from infection and fermentation due to long soaking time and drying regimes.
- Prolonged and unpredictable drying pattern during sundrying

Fig. 16 Typical Small Scale Rice Soaking and Parboiling Set Up

The deficiencies in the traditional methods are largely solved in the modern designs. Modern rice plants are equipped with machinery that gives better results. However the challenge in such plants is for the operators to exercise sufficient control of the unit operations and make the run within the established limits.

Irrespective of the system used the quality of water used for parboiling affects colour, odour and general acceptability of processed rice. Therefore water is an important component for rice processing. Even when there is a water treatment plant, the quality of water used for soaking and steaming must be evaluated regularly. To ensure strict compliance to specifications for water for food processing, the water must be analysed regularly. Some of the chemical components to be analyzed for are:

1. Inorganic constituents- aluminum, ammonia, antimony, arsenic, asbestos, barium, beryllium, boron, cadmium, chromium, copper, cyanide, fluoride, hydrogen sulphide, lead, manganese, mercury, molybdenum, nickel, nitrite/nitrate, selenium, sodium, sulfate, tin, uranium and zinc.

2. Organic constituents- Chlorinated alkenes eg. Carbon tetrachloride, dichloromethane, Chlorinated ethanes eg. Vinyl chloride, 1,1-Dichloroethane, Aromatic hydrocarbons eg. Benzene, toluene, xylenes,styrene

3. Chlorinated benzenes eg. Mono, di, tri- chlorobenzenes

4. Pesticides eg. Alachlor, aldicarb, aldrin/dieldrin, atrazine, DDT etc

5. Disinfectants and Disinfectant by-products

The list is almost endless and it is difficult to be exhaustive in evaluation. It is important that regular and periodic monitoring and analysis is sustained. The presence of certain constituents of the water can affect the quality of the product in addition to safety concerns. The elevated temperatures that occur during parboiling operations will promote chemical interactions and might affect overall quality even in the future. All processing vessels, tanks and indeed all food contact surfaces should be made of food grade stainless steel.

4.05 Instrumentation, basic laboratory testing instruments and meters

It is important that processors install measures to adequately control the process to ensure good quality products. It is therefore important that all the operations are carefully monitored by continuously evaluating the parameters. The processor should have some basic testing equipment in a laboratory set up for this purpose. One major parameter to be tested regularly is the moisture content. Testing for moisture content could be carried out using the methods discussed in section 3.03 but other reliable methods are available. Moisture meters could be used for rapid results these could be used for regular and routine test for moisture content. The effect of moisture content on the preservation of paddy and milled rice cannot be over emphasized. Safe moisture levels are important from the public health point of view in terms of mould growth on the grains and the risk of aflatoxin. It is also important from the economic point of view as a result of losses incurred due to spoilage of the grains. Some large mill carry out some pre milling tests on new raw materials in order to predict the behaviuor of the paddy during milling and to estimate soaking and steaming times.

SECTION 5

RICE MILLING AND FACTORS AFFECTING MILLING EFFICIENCY

5.01 Drying and Conditions of Drying of Parboiled rice

Drying of agricultural products is an important unit operation under the post-harvest phase. It refers to the removal of moisture from grains and others products to a predetermined level. Drying can be either NATURAL OR ARTIFICIAL. An example of Natural drying is SUN DRYING whereas ARTIFICAL OR FORCED drying is the use of heated air forced through the grain mass, causing vaporization of moisture from the grain. Artificial drying is therefore a heat and mass transfer process. After parboiling before milling continues, rice must be sufficiently dry. Improperly dried rice may give rise to faulty milling. Small scale mills and cottage scale processors usually dry under the sun. Two to three days of uninterrupted sunshine will suffice. This dependence on weather conditions results in inconsistent quality because of variable drying rates in addition to risk of infection. It has been found by several experiments that harvesting of crops at high moisture content and subsequently drying to safe moisture level leads to a saving of grains. For example, if paddy is harvested at 20 - 22% moisture content and later on dried to 14% moisture content. It has a potential of increasing rice yield by nearly 10% compared to harvesting paddy at 14% moisture content.

A lot of labour is required to constantly turn and mix the paddy in order to achieve rapid and uniform drying. Parboiled paddy is more difficult to dry compared to the unparboiled and requires more energy because its moisture content is much higher (30-38%).

Modern mills use artificial dryers to dehydrate parboiled rice. This ensures that head rice recovery rate is much higher than those dried under the sun. Hot air is blown into the rice by the use of forced convection air currents generated by fans. The dry hot air picks up moisture from the rice and carries same away until the rice is dry enough for further processing. The system is arranged for optimized drying rates by making the paddy to tumble whilst the air flows past it. Drying should not be too fast, to prevent internal stresses (mostly due to differential expansion and contraction that occur in the different parts of the grain as heat is gained and moisture is lost) from developing within the grain, which can cause breakage during milling. There are mechanical dryers for drying parboiled paddy. Continuous flow dryers are available in many sizes. Choice of size will depend on the capacity of parboiling systems. Parboiled paddy should be dried to about 12% moisture for safe storage or milling. After drying is completed the paddy should be allowed to stand for several hours preferably 1 to 2 days before it is milled to allow for moisture and stress differences to adjust and attain equilibrium, this stage is known as **tempering**. Continuous flow dryers are used by some modern processors.

TABLE 5. Performance Data for Drying Parboiled Paddy with Recirculatory Batch Dryer without Tempering

Drying air temperature (°C)	100	90	80	70	60
Average total yield (%)	72.8	72.7	72.7	73.0	72.3
Average head yield (%)	52.0	50.0	55.0	58.5	61.6

Source: Rama Rao 1974.

A multipass system makes the rice to run through the process a number of times until it is dried. Each pass takes about 30 minutes with the temperature of the heated air being about 50 °C for raw paddy and as high as 90 °C for parboiled paddy. About 2 per cent loss of moisture occurs in each pass. Moisture removal can be accelerated by tempering the grain in a heap or in a silo at the end of each pass. The most common cause of cracking is believed to be either rapid drying or rapid moistening, or both. Cracks are a result of stresses developed in the grains, and they are more frequent in kernels of large sizes. Cracks result in broken grains during milling.

5.02 Fundamentals of Rice Milling and Importance of Various Equipment.

The term milling generally refers to the size-reduction of granular materials, but for food grains the term has different connotations. For grains it is often refers to the production of flour and the operations leading to the grinding to smaller particles. For rice, milling includes operations like dehusking and polishing even without further size reduction.

The major aim of commercial rice milling is to convert paddy rice into white rice with good appearance. Modern rice mills process paddy in sequential stages, hence they are called multi-stage or multi-pass rice mills. The different stages reduce mechanical stresses and heat build up in the grain, thereby minimizing breakage and producing uniformly polished grains that are better than those produced using manual or low tech equipment. The type and design of the milling machinery influence milling output and quality. If the paddy is parboiled before milling, rice breakage during shelling or husking operation is reduced because gelatinization imparts hardness to kernels thereby improving milling quality.

Rice milling unlike other cereals is the process of removing the outer husk and all or part of the bran layer from the grain to obtain an intact (whole) and unbroken grain. A great quantity of rice could be lost during milling therefore milling requires careful planning and use of properly designed and operated equipment.
A rice milling system can be a simple one or two step process or a multi stage process. In a one step milling process, husk and Bran removal are done in one pass and milled or white rice is produced directly out of paddy. In a two step process, removing husk and removing Bran are done separately, and Brown rice is produced as an intermediate product. The initial pass or dehusking removes the husk and the second stage or polishing removes the bran and gives gloss to the rice kernel.

A good rice milling operation should aim to achieve the following:

- Produce the maximum yield of head rice
- Obtain the best possible quality
- Minimize losses
- Minimize processing cost.

A successful milling operation will involve a good combination of good equipment and skill of the miller. With a good quality paddy in a well-maintained mill that is operated by a skilled miller, then the mill will produce high quality head rice. If you use poor quality paddy, then the mill will always produce poor quality milled rice despite the skill of the miller or maintenance of the mill. If the miller is not skilled, then the use of good milling equipment and good quality paddy does not guarantee a high quality product. The mill operators must understand the principles of the process and be comfortable with the machinery involved. If they have acquired a good knowledge base, it is easier for them to adjust to new developments and be able to initiate solutions as problems arise.

5.03 Rice Milling Equipment

Modern milling equipment has rubber rollers rotating in opposite directions at different speeds (Fig. 21). Contact with the rubber rollers creates a shear action on rough rice, which removes the husk from the grain. The mixture of husk, brown rice and unshelled paddy is subjected to sifting and aspiration, which removes the husk. The unshelled paddy is separated mechanically from brown rice. The unshelled paddy is returned to the Sheller. The brown rice is milled to remove the bran and the germ. The milled rice is then polished in a brush machine, which removes the aleurone layer, and adhering particles and yields polished rice. When the mill is correctly adjusted for optimal operation, the rubber roller multi-pass mill produces the highest total recovery and the best head rice yield (Table 6). The modern mill has high investment cost, this discourages many potential investors in modern rice mill.

Table 6: Milling Efficiency of Different Milling Methods

Milling methods	Husk%	Bran%	Total husk and bran	Head %	Broken%	Total head and broken
Hand pounding	-	-	40.0	40.0	20.0	60.0
Steel huller	-	-	36.6	46.5	16.9	63.4
Disc Sheller	-	-	32.5	55.9	11.6	67.5
Rubber roller	22	8	30.0	62.0	8.9	70.0

Source: Esmay *et al.*, 1979.

To move from paddy to rice, paddy passes through several steps namely, Husking, husk separating, paddy separating, polishing and grading. All these steps together are called MILLING and there is a machine to perform each operation. The following terminologies may be known for Better understanding of milling:

1) Head Rice: It refers to the milled whole rice of 3/4 and more of actual kernel size.
2) Broken Rice: Rice kernels which are less than 3/4 of the actual size and are called Broken Rice. It is further divided into three categories (a) Big Broken these include 1/2 to 3/4 of kernel portion (2) small Brokens, these include 1/8 to 1/2 parts of kernel and (3) points- less than 1/8 part of rice grain.
(3) Total Rice: It includes both Head and Broken Rice.

In some rice growing areas rice milling is accomplished by primitive methods such as pounding the paddy in a wooden mortar and pestle followed by winnowing.
Power operated milling equipment is described below.
Hulling: The purpose of hulling machine is to remove the husk from the paddy grain with minimum damage to the bran layer and as far as possible not to break the brown rice.
Due to surface characteristic of paddy it is necessary to apply friction to the grain to remove the husk. Therefore, during hulling, certain percentage of broken can not be avoided. In this respect the construction of the machine, its precision, adjustment and the operation govern the optimum performance and efficiency of the machine and head rice production. The adjustment of the hulling machine depends upon the variety and uniformity of grain. Its uniformity is necessary for best performance of equipment.

5.04 Huller

One of the most common machines used for paddy hulling in is "Engleberg" huller. The working element of this machine is a ribbed cast iron roller. The roller rotates on its axis inside a large concentric cylinder. On the inner cast iron roller, spiral ribbed strips are mounted to 1/4 part of the length and on remaining 3/4 part 4 to 6 straight ribbed strips are mounted (Fig.16). The outer cylinder is made in two parts. The bottom half is fabricated by perforated mild steel sheet and can be changed as per requirement. While hulling, the husk and bran are removed through this perforated portion of the huller. The ribbed roller is rotated at 600 to 900 rpm.

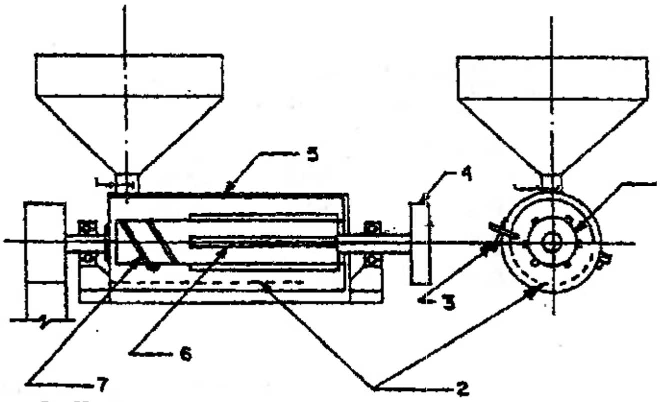

Fig. 17 : Engleberg huller
1. hulling roller 2. screen 3. Knife 4. balancing pulley 5. casing 6. straight ribs 7. spiral ribs

Paddy is fed into the hopper and due to rotational direction of the flutes, it is moved around the cylinder and finally towards the outlet. Friction between the grains and the steel parts of the huller causes the husk and bran to be scrapped off. The huller does the job of husking and bran removal simultaneously, thus mixes the bran and broken with husk. It is difficult to separate these ingredients; therefore, the mixture can not be used for oil extraction and is sold as cattle feed.
A steel blade is provided which can be moved in or out of the casing. Clearance between the blade and ribbed roller decides frictional forces generated on the grains. Friction between the grains and the steel parts of the huller causes the husk and bran to be scrapped off. The capacities of hullers vary from 2.50 to 750 kg/hour. The average yields obtainable from huller are about 56% and 62% for raw rice and parboiled rice respectively. It generates around 25 to 30% broken.

The initial investment in a huller is low, requires little space and can be installed in simple structures. The machine can be locally fabricated and a semiskilled person can operate the huller. But its power requirement per unit rice milled is higher; also it has the lowest recovery rate in total and head rice. Polishing of rice with huller can not be effectively controlled. As stated earlier, because a mixture of husk and bran is obtained, this by product cannot easily be used economically.

5.05 Under-runner disk huller
The under-runner disk huller consists of two horizontal cast iron disk partly covered with an abrasive layer preferably of emery. The top disk is fixed with the body of the machines, while the bottom disk rotates. The rotating disk is vertically adjustable by which clearance between the two disks is adjusted (Fig.17). As per the variety and condition of paddy, the clearance is decided. The condition of abrasive coating on the disks also affects the clearance.

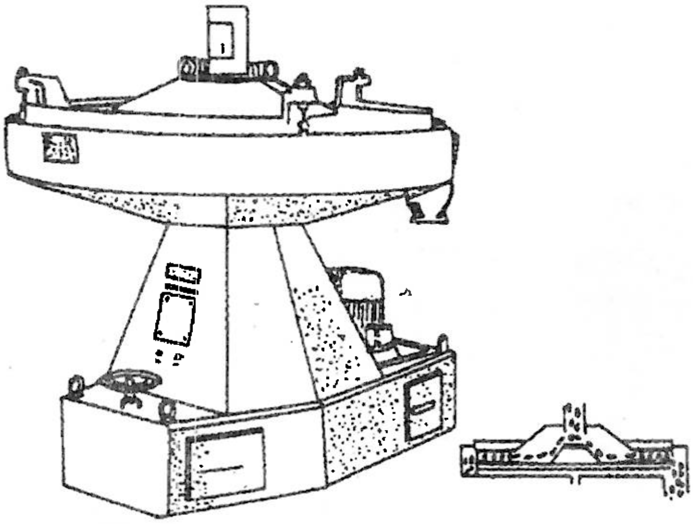

Fig. 18: Under-runner disk huller

Paddy is fed into the equipment from top through a hopper. With an adjustable sleeve uniform flow of paddy is maintained, which also spreads paddy evenly to entire surface of the rotating disk. By centrifugal force the paddy is forced between the disks and dehusking takes place due to friction and pressure.

During hulling there is wear of abrasive coating and is not uniform over the entire surface of the coating. Hulling is mainly concentrated at the centre; therefore, after sometime a ridge is formed at the outer ring of the coating. The ridge causes excessive pressure on the paddy and grain breaks during hulling.

The huller shaft is normally driven by a flat or V-belt transmission. While driving the disk huller with flat belt, care must be taken to ensure that the pulling part of the belt should be perpendicular to the main transmission shaft. If such conditions are maintained, the huller will consume less energy.

Edible grade oil can be extracted from the bran obtained from disk huller. The machine has longer life and the operating cost is low. Parboiled paddy can also be processed by this machine. The total and head rice recoveries are lesser than what is obtainable by rubber-roll Sheller.

5.06 Centrifugal Dehusker

Centrifugal dehusker shells paddy due to impact. The paddy grains are subjected to a centrifugal force by means of a rotating impeller with a rotational speed ranging between 2500-3000 rpm. It creates an impact force sufficient to shell paddy grains. Casing of the dehusker is lined with a rubber sheet (Fig. 18). The paddy is fed to the centre of the rotor form which is thrown towards the casing with great force and is shelled upon hitting the casing. The salient features of the centrifugal dehusker are, its high capacity and simple construction, because there is only one moving part, the impeller. Heating of grain does not take place as there is no grinding or friction action. The initial cost of the machine and the operational cost are low. It requires less power, 1 hp/500 kg paddy dehusking per hour. The total and head rice yield is more than the hullers. The machine needs adjustment according to paddy variety and increased shelling leads to increased breakage of grains.

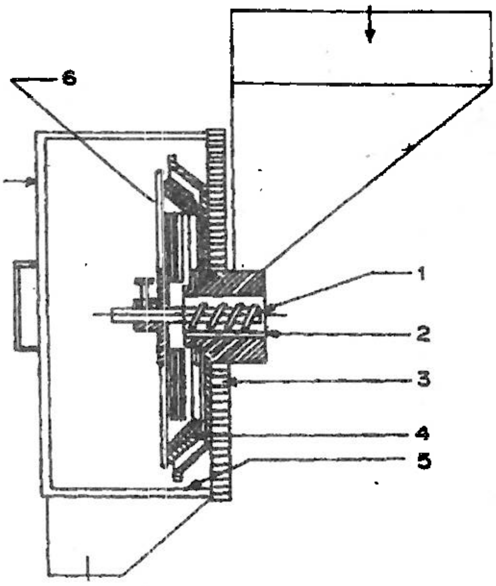

Fig.19: Centrifugal dehusker
1. feed screw 2. collar 3. Crank gear 4. Rubber ring 5. lining 6. impeller 7. lid

5.07 Rubber-roll Sheller
Rubber-roll Sheller consists of two rubber rolls rotating in opposite. Direction at different speeds. A feeder feeds paddy uniformly to the machine (Fig. 19). Paddy is fed in thin layer between the rotating roll by the feeder. One of the roll is fixed while the other is adjustable to obtain the desired

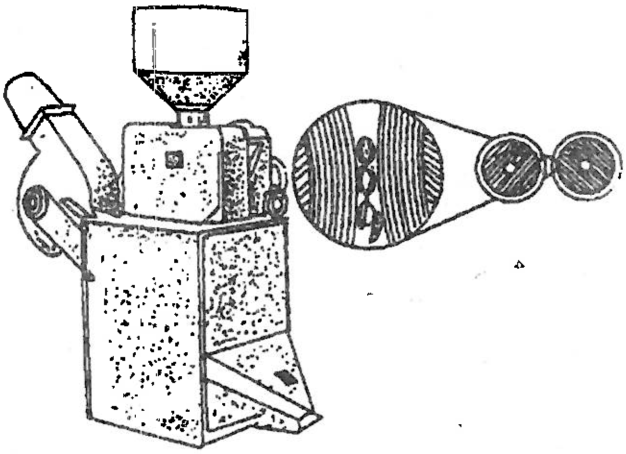

Fig. 20: Rubber-roll Sheller
clearance between them. The rolls are driven mechanically and the adjustable roll normally runs about 25% slower than the fixed one. Difference in surface speeds of the rolls develops a shearing force on the grain surface resulting in the opening and breaking of husk. The clearance between the roll is kept smaller than the thickness of paddy grain. This clearance should be about half the thickness of paddy and may be adjusted subsequently by judging the shelling efficiency. If the gap between rolls is properly adjusted, this equipment can shell up to 95% of paddy fed to

it. When the gap is reduced excess pressure results which will cause more breakage of grain and can also cause coloring of shelled rice. In the modern machines, the gap between the rolls is adjustable by suction methods, therefore, as per need this gap is automatically maintained.
During shelling the faster roll should have a peripheral surface speed of 10 to 13 *m/s,* while the slower roll 8-10 *m/s.*To obtain optimum hulling efficiency or performance, the grain should be evenly distributed over the full width of the rolls. In case of non-uniform distribution, roll surface wears out unevenly.

5.08 Husk separator

This machine is required to blow away husk from the mixture of shelled rice, husk and unshelled paddy obtained from huller/Sheller. In the first stage the husk, broken, germ and bran must be separated which is accomplished by the husk separator. It is a simple machine having a fan and an arrangement to distribute the product of the Sheller uniformly on an oscillating sieve with fine perforations. This is done to ensure that air flows across uniformly and blow away the husk. The broken, germs and bran are separated through perforations while the immature grains are also blown away by fan. The compact, lightweight construction of the rubber-roll husker makes is possible to combine it with husk aspirator. The rubber roll Sheller does not damage the bran layer of the brown rice and so the discharge is free of bran. It produces little amount of broken. Therefore, with rubber-roll, a plansifter is not required and only a husk aspirator is used

5.09 Paddy separator

All the paddy dehuskers, like huller, disk huller, centrifugal dehusker or rubber roll Sheller are not able to remove 100% husk from paddy. About 80 to 95% husking can be achieved through these machines depending on their efficiency. In addition to this the quantity of unshelled paddy with brown rice depends on the following factors:

1.Uniformity of paddy

2.Variety of paddy

3.Condition of paddy

4.Husking machine

5.Condition of husking machine

6.Operator's skill

SECTION 6

QUALITY CONSIDERATIONS IN MILLED RICE

6.01 Factors Affecting Good Milling Characteristics

The six major physical characteristics of paddy that are important quality indicators are shown in Table 7

Table 7. Major Physical Quality Parameters of Rice Paddy

Characteristics	Description
Moisture Content	Moisture content has a significant influence on all aspects of paddy quality. To obtain high yield it is essential that paddy be milled at the proper moisture content. Paddy is at its optimum milling potential when its moisture content is 14%.
Varietal purity	A mixture of varieties in a sample of paddy causes difficulties in parboiling and milling and usually results in reduced milled capacity, excessive damage, lower milled rice recover and reduced head rice yields.
Percent Cracked	Over exposure of mature paddy to fluctuating temperature and moisture conditions leads to development of cracks in individual kernels
Percent discolored	Water, insects, microbial infection and heat exposure, can cause paddy to deteriorate through biochemical changes in the grain which may result in the development of off odour and changes in physical appearance
Percent dockage	Dockage include chaff, stones, weed seeds, soil, rice straw, stalks and other foreign matter. These impurities generally come from the field or from the drying floor.
Percent immature	Immature rice kernels are very slender and chalky and result in the production of excessive bran, broken grains and brewer's rice.

6.02 Rice Polishing - Its Importance in Competitive Marketing.

The term "polished rice" refers to milled rice that has gone through polishers that remove loose bran adhering to the surface of milled rice and improves its translucency. The polisher has a horizontal or vertical cylinder or cone, covered with leather strips, which gently remove loose bran as they are rotated in a working chamber made of wire mesh screen or a steel screen with slotted perforations.

Polished rice has lost most of the germ and outer layers with them, most of the B-vitamins and some protein and minerals. Millers are however constrained to produce for the market which demands white rice which has a bland neutral taste and are easily digestible. The advantages of polished rice from the trade point of view are:

- They are white and more attractive in appearance
- They have less fat and hence less tendency to become rancid.
- They have less phytic acid which means that minerals can be absorbed better.
- Polished rice has a much longer shelf life than the unpolished.
- Fats on the surface cells of milled rice undergo rancidity which causes off odour.

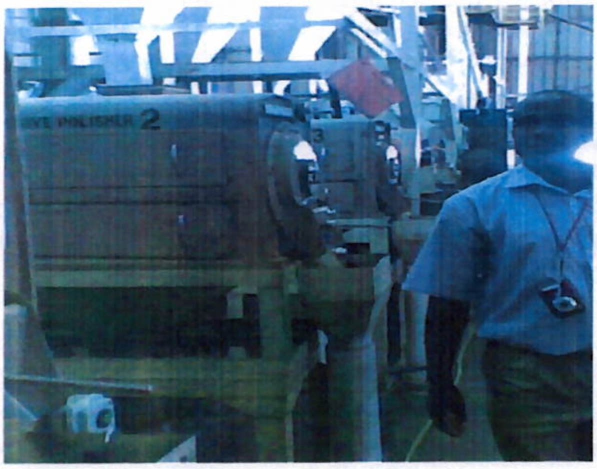

Fig 21 Modern Rice Polishing Machines

6.03 Quality Considerations in Rice Processing

1. Physical Characteristics

a. Degree of Milling

The degree of milling is a measure of the percent bran removed from the brown rice kernel. Milling degree affects milling recovery and influences consumer perception and acceptance. Apart from the amount of white rice recovered, milling degree influences the colour and also the cooking behaviour of rice. Unmilled brown rice absorbs water poorly and does not cook as quickly as milled rice. The water absorption rate improves with degree of milling progressively up to about 25% milling degree after which, there is very little effect.

b. Head rice

"Head rice "or head rice percentage is the weight of head grain or whole kernels in the rice lot. Head rice normally includes broken kernels that are 75% of the whole kernel. High head rice yield is one of the most important criteria for measuring milled rice quality. Broken grain has normally only half of the value of head rice.

The actual head rice percentage in a sample of milled rice depends on varietal characteristics (i.e. the potential head rice yields), production factors, harvesting, drying and milling process. In general harvesting, drying, and milling are being responsible for some losses and damage to the grain.

c. General appearance / colour

This is particularly important because most rice is consumed in the head rice form. Numerous factors constitute general appearance including grain size and shape, uniformity, translucency, chalkiness, color, damaged and imperfect grains. These are subjective observations as performed by the human eye. Although there have been recent advances in automating the process. General appearance of the milled rice is frequently the first quality rating assigned to a lot of milled rice.

d. Physical dimensions

Since rice is produced and marked according to grain size and shape, the physical dimensions and uniformity are of prime importance. Grain type categories are based upon three physical qualities; length, width and weight (Table2). Grain size and shape are among the first criteria of rice quality that breeders consider in developing new varieties. Other physical properties that could be evaluated are; seed-weight, length to diameter ratio, specific gravity, bulk density, seed colour, angle of repose and seed coat to endosperm ratio.

e. Whiteness

Whiteness is a combination of variety, physical characteristics and the degree of milling. In milling, the whitening and polishing greatly affects the whiteness of the grain. During whitening, the silver skin and the bran layer of the brown rice is removed. Polishing after whitening is carried out to improve the appearance of the white rice. During polishing some of the bran particles stick to the surface of the rice is removed.

f. Chalkiness

If part of the milled rice kernel is opaque rather translucent, it is often characterized as "chalky" Excessive chalkiness is caused by interruption during the final stages of grain filling. Though chalkiness disappears upon cooking and has no direct effect on cooking and eating qualities, excessive chalkiness downgrades the quality and reduces milling recovery.

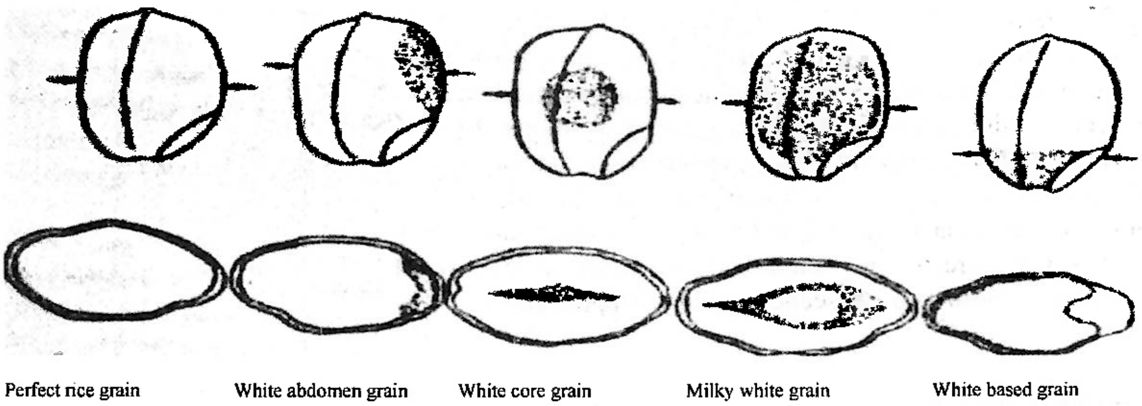

Fig 22 Different Positions of the Whitish Opaque Part of Rice

Perfect rice grain is highly found in small-sized and long grain varieties but less in large-sized rice varieties which are liable to become white abdomen and white core rice.

g. Percentage Damaged

Grains which are fully or partially darkened as a result of insect, mold, water or heat damage. The presence of even a few damaged grains can severely downgrade rice.

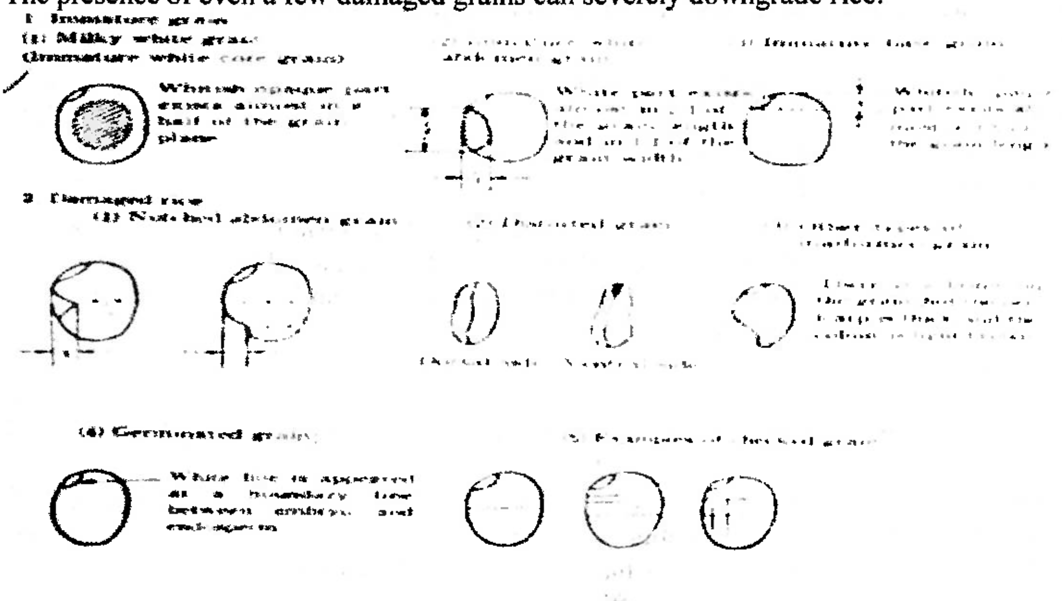

Fig 23 IMMATURE and MALFORMED RICE

h. Percentage Broken or Brewers Rice

Rice is priced highly when whole and intact. Broken grain attract less price in the market and can be used for rice flour or brewers rice.

6.04 Chemical Characteristics

a. Gelatinization temperature:

The time required for cooking rice is determined by gelatinization temperature (GT). This refers to the water temperature at which at least 90% of the starch grains have been gelatinized or swollen irreversibly in hot water. Environmental conditions, such as temperature during ripening, influence GT. A high ambient temperature during development results in starch with a higher GT. The GT of milled rice is evaluated by determining the alkali spreading value. In many rice – growing countries, there is a distinct preference for rice with intermediate gelatinization temperature. GT are classified as low (55-69.5^{O}C), intermediate (70-74^{O}C) and high (74.5-80 ^{O}C). The GT also affects some functional properties such as water absorption capacity, and swelling capacity. These also influence consumer's preferences.

b. Amylose Content:

Starch makes up about 90% of the dry matter content of milled rice. Starch is a polymer of glucose and amylose is a linear polymer of glucose. The amylose content of starches usually ranges from 15 to 35%. High amylose content rice shows high volume expansion (not necessarily elongation) and high degree of flakiness. High amylose grains cook dry, are less tender, and become hard upon cooling. In contrast, low – amylose rice cooks moist and sticky. Intermediate amylose rice is preferred in most rice- growing areas of the world, except where low – amylose japonicas are grown.

Based on amylose content, milled rice is classified in "amylose group", as follows:

- Waxy (1-2% amylose)
- Very low amylose content (2-9% amylose)
- Low amylose content (10-20% amylose)
- Intermediate amylose content (20-25% amylose) and
- High amylose content (25-33 amylose).

Amylose content of milled rice can be determined by using the colorimetric iodine assay index method. The non amylose starch is known as amylopectin. The amylose : amylopectin ratio also affects some functional properties such as water absorption capacity, and swelling capacity. These also influence consumers preferences.

6.05 Packaging of Finished Products; Grading, Branding and Sizes of packaging

Grain grading is a set of standard procedures and methods in quality determination which is essential in marketing, quality assurance operations and varietal improvement program. Grading is necessary in development of quality standards that define the relationship between grades and prices in the assessment of the value of grains. Official standards are important in the marketing process because they furnish the means of describing variations in quality. They also provide a

basis for merchandising contracts, quoting prices for sorting and blending by producers to meet market requirements. Grading then provides for an orderly marketing and trading system.
When grades and prices are defined the farmers become virtually interested in producing better crops because with grading, it is assured that returns are based on the quality of their produce.
With better crops procured, quality assurance in other post–harvest operations become more manageable. Grading is conducted at regular intervals in the various stages of post-harvest operations as a means of quality monitoring. Quality has become one of the dominant factors for consideration in rice industry and the first step towards the achievement of quality rice is grading.
After milling, the rice is graded based on the shape, length and color to give the final product a uniform look. Discoloured kernels are removed by colour sorters, and broken grains are separated from head rice, by using indented cylinders, plan sifters and drum graders. The uniform grain length and size renders a nice appearance while adding value to the finished product.

The graded product may be packaged in clean woven polypropylene bags of 50kg capacity and or other smaller convenient sizes depending on the end users choice. The packages are branded and labeled according to the available grades before they are sent out for marketing. It is best to place the finished product in a suitable package at the end of the production process. The benefits of proper packaging of food products include:

- improved protection of the food from contamination leading to increased shelf-life
- products reaching the consumer while maintaining good quality
- package can be used to decorate a product and make them attractive so that they can match and compete with others in the market
- it is an avenue to brand the product to make it easily identifiable in the market for consumers to select
- when re-usable containers are used it becomes an incentive for consumers to select the product in addition to being environmentally friendly
- tamperproof packages reduce the risk of adulteration,- different sizes can be introduced for the convenience of the consumers
- making foods more easily handled and stored by sellers and consumers
- increased production output as a longer shelf-life enables a larger market to be found and year round production possible
- it makes for easy size differentiation and convenient pricing
- provide valuable information to the consumer and handlers on use, nutrition, safety, tracking etc.

SECTION 7

WASTES AND BY PRODUCTS FROM RICE PROCESSING

7.01 Wealth from Waste Concept in Rice Processing:

Although, the main objective of rice processing is to produce whole head rice, it is obvious that the processing leads to losses in the form of products and wastes. These losses if properly harnessed could serve as raw materials for household, agricultural and industrial uses. The main wastes obtained from rice processing include rice hulls/husk, bran and broken grains.

a. Rice hulls/husks:

Rice hulls/husks make up to 25% of wastes obtained during rice processing. The major use of the hulls in the industry is for the generation of energy through firing of boilers. It is known to possess high calorific value (3500 kcal/kg). The steam generated is used for parboiling paddy. Husks are used as roughage for cattle feed, chicken litter and as filler aids. They serve as abrasives and binders for pelleted feed. Rice hulls are used as binders and absorbents for pesticides. One of the most successful uses of rice hulls is for mopping up oil spillage on the surface of water. After skimming off the hulls, the water is left clean enough to drink. Boards and briquettes can also be produced from rice husk. Ashes produced from rice hulls are sources of high-grade silica. There are used in the manufacture of water glass (sodium silicate) and building blocks and other building materials. They are also used as absorbents, soil conditioners, carriers for pesticides. Pure silicon used for making semi conductors is a very costly material that can be obtain from husk.

b. Rice bran:

Rice bran has a high nutritive value. Besides protein, rice bran is an excellent source of vitamin B and E as well as oil. The oily nature of the bran makes it a good binder for animal feeds. Defatted rice bran contains higher protein and other nutrients. When stabilized, defatted rice bran can provide nutritional fortification at levels up to 15% for bakery products such as yeast-raised goods, pancake mixes and biscuits. Rice bran improves flavor, increases water absorption without the loss of volume in the product. The addition of defatted rice bran to bakery goods does not affect the mixing tolerance or the fermentation process. Defatted rice bran is also used in breakfast cereals. Rice bran also finds use in some industries such as those involved in mushroom, single cell protein and industrial enzyme production. They serve as substrate for the microorganisms involved in the production process.

c. Rice bran oil:

Rice bran contains 10 to 23 % bran oil. The oil can be extracted by mechanical or solvent methods. Refined bran oil is suited for use in shortenings, cooking and saladoils and as a pan – release agent in baking operations.

d. Rice bran wax:

About 3 to 9% of the total rice bran oil is wax. The wax together with a small quantity of solid glycerides is removed during the refining of rice bran oil. The waxes are used mostly in cosmetic products.

e. Broken grains:

Broken rice is used as a brewing adjunct. It supplies enough starch necessary during the sacharification process that imparts on the stability of beer. The broken rice grains can also be processed into flour. This can be packaged and sold for production of flour, confectionery food products and local snacks or used as dusting powder in packing of baked products.

Rice waste products are additional sources of revenue, therefore there is need to modernize the method and machinery for by product utilization, so as to substantially reduce the waste generated in rice mills. This will convert such wastes into wealth.

SECTION 8

MACHINERY OPERATIONS AND MAINTENANCE IN RICE PROCESSING

While rice milling factories differ in size, machines and equipment employed at every stage of processing at each factory perform basically the same functions. However, variations exist in terms of configuration, complexity, extra features and capabilities such as technology, capacity and speed of the machines used. Thus, the quality of the final product not only depend on the availability of all the machines required but more importantly, understanding their operations and maintenance procedures.

8.01 Operations of processing equipment (Process flow chart and machine classification)

The flow diagram below summarizes the process stages of rice processing.

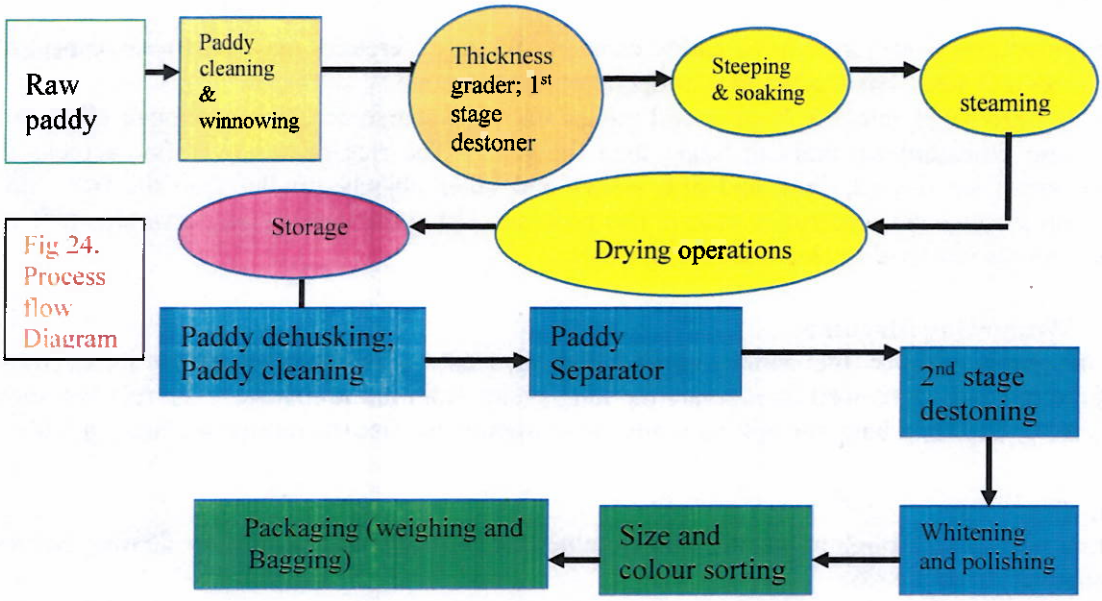

Fig 24. Process flow Diagram

The machines can be classified in 4 ways by functions:

- Cleaning – paddy cleaner, winnower, thickness grader and destoner
- Parboiling – soaking, steaming and drying
- Milling and sorting – dehuskier, whitener, polisher and grain sorter
- Packaging – weighing and bagging
- Auxiliaries – Generators, boiler, water treatment plant, Conveyors and Elevators

8.02
Mechanization in Rice Processing

CLEANING – PADDY CLEANER, WINNOWER, THICKNESS GRADER AND DESTONER

Paddy Cleaning

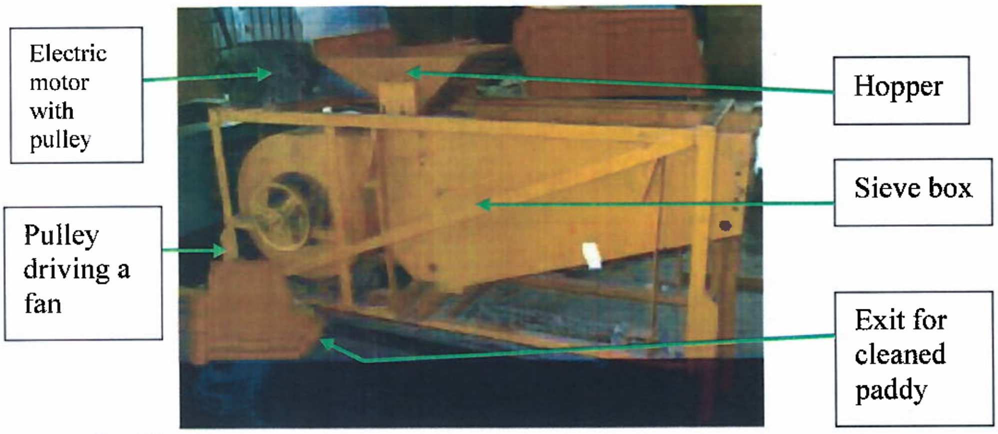

Fig 25: Paddy Cleaner

There are several configurations of paddy cleaners. While differences may exist with respect of their drives and sizes, basic principles of operation are the same.
Paddy is introduced into the hopper and passed through coarse screens to remove all straw, stones, and other objects that are larger than the Rice. The rice passes over fine screens to remove small weed seed, sand and dirt, stones and other objects smaller than the rice. Air separation systems are sometimes used in this process. Using the appropriate sieve, this type of cleaner can also be used to clean rice for milling.

a. Winnowing Machine

Like the paddy cleaner, the winnowing machine also uses a fan to separate the paddy from remnants of pinnacle as well as separate the long grains from the immature. The required long grains are collected in bags for milling while the immature are discarded (also see Section 3.01)

b. Destoner

The rice is passed through a specific gravity table that separates the product by density. Stones are separated from the rice.
The destoner consists of a sturdy supporting frame, the shacking mechanism, vibrating deck, the ventilator and its drive motor. A pipe is installed for dust extraction. Inside the frame is a sieve

which is driven by the electric motor through 2 eccentrics. These eccentrics are responsible for agitation of the sieve which is sloped downwards.

Rice enters through the hopper and through a flap and/or sluice valve which ensures that rice spread over the inclined deck is uniform and regulated. An air current from below and the simultaneous vibration of the deck cause the rice to "split up" – the heavy particles (stones, metallic particles) move up to the higher level of the deck to its outlet while clean rice flows on an air cushion towards the lower edge and collected. The efficiency of the machine depends on air quantity, speed and slope of the vibrating screen. These must be properly determined or adjusted.

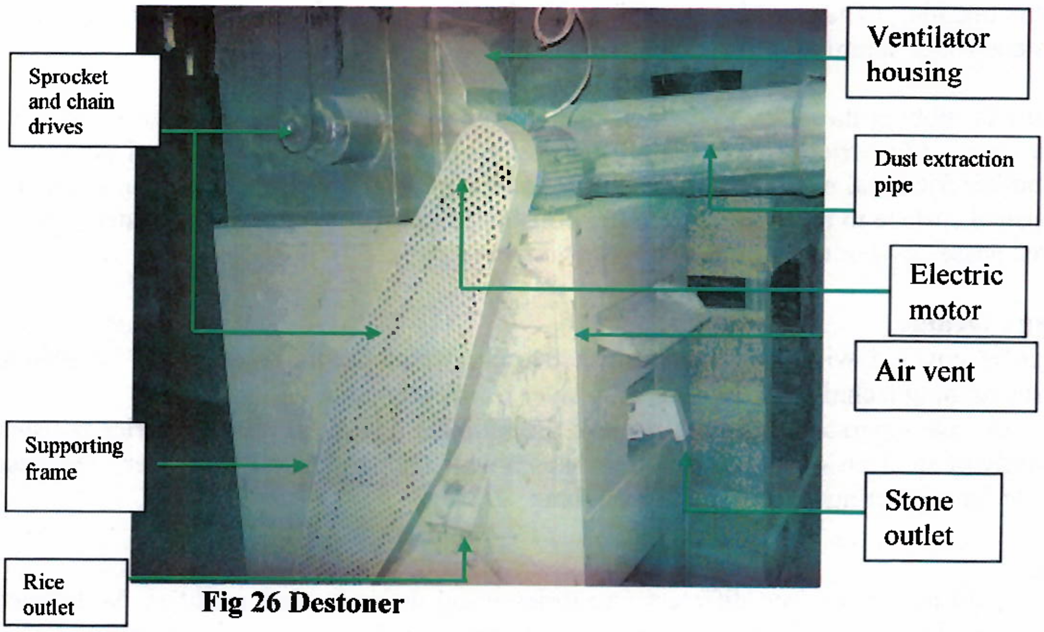

Fig 26 Destoner

c. Parboiling tanks: Soaking and Steaming Tanks
Rice milling plants can operate a system using simmered water at 70°C for soaking and later passing steam over paddy in different vessels in an alternate order.

d. Drying of Paddies
Drying of parboiled paddy using heated cross flow dryers or other methods as previously described.

8.03 Milling and sorting – dehusker, whitener, polisher and grain sorter

"Husk is a layer of cellulose protecting rice grain. Each paddy grain has 2 "half husk" interlocking each other, so it is easier to break the interlock and release 2 half husks from each paddy, this is the concept of Husking machine".

"The husk is removed from the rice. This is most often done by passing the rice through two spinning rubber roles. One roll is spinning faster than the other. The rubber rolls are tightly pressing against the rice from both sides and strip the husk off".

a. Husk/Paddy Separating

"After husking, brown rice/husk/paddy passed through husk separating step, which is separating husk (lighter in density) from the rest (heaver density). This can be done by sieve or ventilations".

"There are many machines and methods designed to remove bran from the rice. The Japanese milling system is most often used in the most modern mills. With this system, the rice is first passed through a milling chamber that has an abrasive stone spinning in the centre and a metal screen on the outside. (The abrasive system). The rice then passes through a milling chamber that has a metal roller spinning in the centre and a scarified metal screen on the outside.

This machine is rubbing the many kernels of rice against themselves and the screen in order to remove the bran. (The frictional system). The last pass (sometimes all frictional passes) is basically another frictional machine that is applying a mist of water to facilitate milling and add a smooth polished surface to the rice. (The water polishing system). This Japanese system can be done in three passes as described here, or as many as seven passes."

b. Polishing Machine

"Brown rice is covered with bran layer which densely wraps around each grain. Polishing machine uses rubbing technique to remove bran layer from each grain."

Some factories use separate polisher to achieve the ultimate quality of rice. The rice polisher consists mainly of an electric motor and a drum screen which houses the milling roller. The later is responsible for separating the white rice from bran.

c. Grading

Milled rice could be graded into different categories using their physical qualities. Milled rice could be passed through different types of sieves to take out broken rice. The milled whole kernel rice could also be passed through an electronic sorter to remove rice with colour defects. The rice is passed before an "electronic eye" that detects any difference in colour. A jet of air removes defective grains. Usually damaged kernels (with black specks), yellow kernels, and stones are removed. The very best mills pass the rice through two breaks of sorters. Sorters can be adjusted to remove green immature kernels from brown rice, chalky rice from white (more translucent kernels) rice, or regular medium grain rice from chalky mochi rice. There are special sorters to remove glass from rice".

Fig. 27 Typical Rice Colour Sorter

"Milling the rice can yield as many as 4 to 40 percent broken kernels depending on the quality of the incoming rice, the milling equipment and operation. Most high quality rice is sold with less than 4 percent broken and so brokens must be removed in the milling process. The rice is passed through indent graders. These can be cyclinders with small pocket too small for whole grain to fit into, but just right for brokens, or disks within a trough that have similar indents. Either way, the idea is for the brokens kernels to temporarily fit into the indent so that they will be picked out of the whole kernels and then thrown into a separate flow. The brokens can then be passed over screens or additional indent graders to be further separated into various sizes. (brewers, screening, and second heads)".

c. Bucket Elevators, chain and belt conveyors

These are used for paddy transport to various machines in use. The bucket elevators consist of an electric motor as the driver; an endless belt and buckets strapped on the belt both of which run together inside a trunking. The top, discharge end is made into a hood to enable discharge of the product while the bottom has tensioning devices to avoid sagging of the belt.

8.05 Maintenance and Cleaning Regimes in Rice Processing Equipment

The efficiency of the machines, actually dictate the appropriate cleaning regime. Some equipment and operations create more wastes than others. Also some work environment are easier to clean than others. A relationship therefore exists between the plant environment and maintenance schedule.

Two maintenance schedules are generally applicable in an industrial setup:

1.PREVENTIVE MAINTENANCE (TIME BASED OR TURN AROUND)

2.BREAKDOWN MAINTENANCE.

It may be argued that the scale of operation at some plants is not high enough for a time based maintenance programme but none of the less prevention is a lot cheaper than avoidable breakdown.
Electric motors working in a dusty environment will need regular cleaning of the fins and cooling fan blades to improve cooling of the motor.
Roller bearings need regular greasing through the nipples.
Hammer beaters normally wear with usage. At regular intervals they are to be inspected and rebuilt or reversed depending on design.
Drive belt tensions should be confirmed regularly.
Cleaning in a food factory is of utmost importance. All machinery and equipment must be cleaned regularly as part of its maintenance. Repairs and maintenance activities are not complete without doing a good cleaning of the environment. It is also important to take cleaning into consideration in the design of new equipment. Equipment with poor sanitary design can constitute a risk for product contamination and public health safety.

DAILY
(Performed by Operator)

- Check operation of conveyor controls. Ensure that all "STOP" push buttons operate properly. Also ensure that all limit switches function properly.
- Clean any accumulation of dust and/or dirt from the conveyor surfaces and remove any accumulation of debris. Do this with the conveyor belt stopped. Never touch a moving belt or rotating part.
- Ensure belt is tracking properly. **NEVER TOUCH A MOVING BELT.**
-

WEEKLY

- (Safety) Observe all safety precautions. Turn off conveyor except when operations must be performed with equipment running. **NEVER TOUCH A MOVING BELT OR ROTATING PART.**
- (Examine Controls and Wiring) with the conveyor shut down and disconnected, look for damage to conduit and wiring. **DO NOT TOUCH LOOSE WIRES.**
- (Examine Motor and Reducer) with the conveyor shut down, look for damage to motor and reducer housings. Look for evidence of lubricant leakage from gear case. If leakage is detected, check for proper oil level. Add oil if required. (Lubricant: Texaco Multigear EP-85W-140 or equivalent). . .
- (Clean Conveyor) Remove any accumulated debris from beneath the surfaces of the conveyor. **MAKE SURE CONVEYOR IS LOCKED OUT.**

- (CLEAN UP) Restore conveyor to its original status. Ensure all inspection equipment is removed from work area. Initiate repair work orders as required. Report serious deficiencies to the maintenance supervisor.

MONTHLY

- (EXAMINE PULLEYS & BEARINGS) With the conveyor running, listen for abnormal noise coming from any pulley assembly or bearing. All pulley bearings should be lubricated every four to six weeks. Tighten set screws as needed.
- NEVER TOUCH A ROTATING PART. USE A METAL ROD TO TRANSMIT SOUND TO YOUR EAR AND NOTE ANY EXCESSIVE BEARING NOISE. NEVER REACH UNDER OR INTO THE CONVEYOR WHEN THE BELT IS RUNNING. FOR ACCESS TO SOME PULLEYS, COVERS MUST BE REMOVED IN MATING BOOM SECTIONS. USE METAL ROD TO REACH THROUGH ACCESS WINDOWS TO CONTACT BEARINGS. SEE ASSEMBLY DRAWINGS FOR LOCATIONS.

- (EXAMINE BELT) With the conveyor running, look for damage to belt or belt lacing. Remove any raveled edges or cord that might catch on pulley assemblies. Also repair or replace belt lacing that show physical damage. **NEVER PERFORM ANY WORK ON THE BELT WHILE IT IS MOVING.**
- (RETURN ROLLERS) Using a metal rod, contact the protruding ends of the hex shafts to listen for abnormal bearing noise. Remove window covers to gain access to some roller shafts. Never reach your hand through these windows when the belt is running. Replace all covers when done. Never reach under the machine when the belt is running.
- (EXAMINE MOUNTING BOLTS) Check all drive motors by jogging units to ensure mounting bolts are tight. Check conveyor hold-down bolts to ensure conveyor will not come loose from floor hold-down devices.
- (ELECTRICAL CABLE REEL) Inspect electrical cable to ensure that cable is not pulling out from a cable connector. Also completely extend and retract the conveyor observing the recoil of the cable. If cable is sagging, completely extend the conveyor and attempt to add an additional wrap to the spring at the reel housing. (Do not over tension spring by over wrapping cable). See manufacturer's literature.
- (ELECTRICAL WIRING) Check all electrical conduit and fittings to ensure damage has not been done to the system. Fix damaged, loose or bare wiring or connections.
- (CLEAN UP) Restore conveyor to its original status. Ensure all inspection equipment is removed from work area. Initiate repair work orders as required. Report serious deficiencies to the maintenance supervisor.

QUARTERLY

- (CAM ROLLER LUBRICATION AND ADJUSTMENT) Inspect and adjust cam rollers. Both front and rear cam support blocks have provisions for lubrication. Front blocks can be lubricated without guard removal. To lubricate rear cams, the rear guard must be removed. All cam rollers should be checked for proper adjustment. (See boom alignment instructions.) **MACHINE SHOULD BE LOCKED OUT FOR THIS PROCEDURE.**
- **d. SEMIANNUALLY**

- (CHANGE FLUID IN GEAR BOXES) Twice a year the gear head lubricant should be changed. The gear cases should be drained and cleaned. Fill units with Texaco Multigear EP-140 or equivalent. (Note: Cold weather applications may require a thinner grade oil).When adding oil to any gear box the following procedure should be followed:
    - Remove the oil level plug in the side of the box that controls the oil level height.
    - Remove the fill line plug located on the top of the gear box.
- Add lubrication through the top fill line port.
- Add lubricant until it runs out of the fluid level line hole. **CAUTION: DO NOT OVER FILL GEAR BOX WITH OIL.**
- 5) Replace both plugs in gear box. **ELECTRICAL LOCKOUT REQUIRED.**
- (EXAMINE MASTER CONTROL PANEL) Wipe dust from exterior of panel. Open panel door. Remove dust from interior of panel **(DO NOT TOUCH WIRES)**. Look for burned wiring and loose terminal connections. Close panel.
- (OBSERVE DRIVE SECTION) With the conveyor running, carefully contact motor and reducer housing **WITH METAL ROD** to detect excessive vibration from bearings or gears. Listen for evidence of wear or damage to internal parts. **DO NOT GO NEAR MOVING PARTS.**

Care of elevators:

-check belt for fatigue and elongation

-ensure the buckets are well fastened on the belts

-ensure that belts are well aligned to avoid touching the trunking (risk of dust ignition and explosion). Install misalignment detectors.

-Care of chain and belt conveyors

- check belt fatigue, chain links and elongation. Check rollers.

8.06 Principles of Steam boiler Operation

Boilers are fuel-burning appliances that produce either hot water or steam that gets circulated through piping for heating or process uses. Boiler systems are major financial investments, yet the methods for protecting these investments vary widely. Proper maintenance and operation of boiler systems is important with regard to efficiency and reliability. Without this attention, boilers can be very dangerous.

a. Types of Boilers

Boiler designs can be classified in three main divisions—fire-tube boilers, water-tube boilers, and electric boilers.

b. Fire-Tube Boilers

Fire-tube boilers rely on hot gases circulating through the boiler inside tubes that are submerged in water. These gases usually make several passes through the tubes, thereby transferring their heat through the tube walls and causing the water to boil on the other side.

c. Water-Tube Boilers

In the water-tube boiler, gases flow over water-filled tubes. These water-filled tubes are in turn heated

d. Electric Boilers

Electric boilers are very efficient sources of hot water or steam, which are available in ratings from 5 to over 50,000 kW. They can provide sufficient heat for any HVAC requirement in applications ranging from humidification to primary heat sources connected to large containers called drums.

e. Boiler care - Maintenance

Good maintenance and efficiency start with having a working knowledge of the components associated with the boiler and keeping comprehensive records, and end with details such as cleaning heat transfer surfaces and adjusting the air-to-fuel ratio.

General Requirements for a Safe and Efficient Boiler Room

- Keep the boiler room clean and clear of all unnecessary items. The boiler room should not be used as a storage area. The burner requires proper air circulation in order to prevent incomplete fuel combustion. Use boiler operating log sheets, keep maintenance records, and monitor the production of carbon monoxide.
- Ensure that all personnel who operate or maintain the boiler room are properly trained on all equipment, controls, safety devices, and up-to-date operating procedures.
- Before start-up, ensure that the boiler room is free of all potentially dangerous situations, like flammable materials, or mechanical or physical damage to the boiler or related equipment. Clear intakes and exhaust vents; check for deterioration and possible leaks.
- Ensure that a thorough inspection is done by a properly qualified inspector.
- After any extensive repair or new installation of equipment, make sure a qualified boiler inspector re-inspects the entire system.
- Monitor all new equipment closely until safety and efficiency are demonstrated.
- Use boiler operating log sheets, maintenance records, and manufacturer's recommendations to establish a preventive maintenance schedule based on operating conditions, past maintenance, repair, and replacement that were performed on the equipment.
- Establish a checklist for proper startup and shutdown of boilers and all related equipment according to manufacturer's recommendations.
- Observe equipment extensively before allowing an automating operation system to be used with minimal supervision.
- Establish a periodic preventive maintenance and safety program that follows manufacturer's recommendation

Fig 28 leakage from steam Pipeline

Table 8. Boiler Maintenance Checklist

Description	Comment	Maintenance frequency			
		Daily	Weekly	Monthly	Annually
Boiler use and sequencing	Turn off or sequence unnecessary boilers	×			
Overall visual inspection	Complete overall visual inspection to be sure all equipment is operating and that safety systems are in place.	×			
Follow manufacturer's recommended procedures in lubricating all components	Compare temperatures with tests performed after annual cleaning.	×			
Check steam pressure	Is the variation in steam pressure as expected under different loads? Wet steam may be produced if the pressure drops too fast.	×			
Check unstable water level	Unstable levels can be a sign of contaminates in feed water, overloading	×			

	of boiler, or equipment malfunction.				
Check burner	Check for proper control and cleanliness.	×			
Check motor condition temperatures	Check for proper function.	×			
Check air temperatures in boiler room.	Temperatures should not exceed or drop below design limits.	×			
Boiler blowdown	Verify the bottom, surface and water column blow downs are occurring and are effective.	×			
Boiler logs	Keep daily logs on: • Type and amount of fuel used • Flue gas temperature • Makeup water volume • Steam pressure, temperature, and amount generated Look for variations as a method of fault detection.	×			
Check oil filter assemblies	Check and clean/replace oil filters and strainers.	×			
Inspect oil heaters	Check to ensure that oil is at the proper temperature prior to burning.	×			
Check boiler water treatment	Confirm water treatment system is functioning properly.				
Check flue gas temperatures and composition	Measure flue gas composition and temperatures at selected firing positions — recommended O_2% and CO_2%. Fuel O_2% CO_2% Natural gas 1.5 10 No. 2 fuel oil 2.0 11.5 No. 6 fuel oil 2.5 12.5 Note: percentages may vary due to fuel composition variations		X		
Check all relief valves	Check for leaks.		X		
Check water level control	Stop feed water pump and allow control to stop fuel flow to burner. Do not allow water level to drop below recommended level.		X		
Check pilot and burner assemblies	Clean pilot and burner following manufacturer's guidelines. Examine for mineral or corrosion buildup.		X		
Check boiler	Stop fuel flow and observe flame		X		

operating characteristics	failure. Start boiler and observe characteristics of flame.				
Inspect system for water or steam leaks and leakage opportunities	Look for: leaks, defective valves and traps, corroded piping, and condition of insulation.		X		
Inspect all linkages on combustion air dampers and fuel valves	Check for proper setting and tightness.		X		
Inspect boiler for air leaks	Check damper seals.		X		
Check blowdown and water treatment procedures	Determine if blowdown is adequate to prevent solids buildup.			X	
Flue gases	Measure and compare last month's readings for flue gas composition over entire firing range.			X	
Combustion air supply	Check combustion air inlet to boiler room and boiler to make sure openings are adequate and clean.			X	
Check fuel system	Check pressure gauge, pumps, filters and transfer lines. Clean filters as required.			X	
Check belts and packing glands	Check belts for proper tension. Check packing glands for compression leakage.			X	
Check for air leaks	Check for air leaks around access openings and flame scanner assembly.			X	
Check all blower belts	Check for tightness and minimum slippage.			X	
Check all gaskets	Check gaskets for tight sealing. Replace if they do not provide a tight seal.			X	
Inspect boiler insulation	Inspect all boiler insulation and casings for hot spots.			X	
Steam control valves	Calibrate steam control valves as specified by manufacturer.			X	
Pressure reducing or regulating valves	Check for proper operation.			X	
Perform water quality test	Check water quality for proper chemical balance.			X	
Clean waterside surfaces	Follow manufacturer's recommendation on cleaning and preparing waterside surfaces.				X
Clean fireside	Follow manufacturer's recommendation on cleaning and preparing fireside surfaces.				X

Inspect and repair refractories on fireside	Use recommended material and procedures.				X
Relief valve	Remove and recondition or replace relief valves.				X
Feed water system	Clean and recondition feed water pumps. Clean condensate receivers and deaeration system.				X
Fuel system	Clean and recondition system pumps, filters, pilot, oil preheaters, oil storage tanks, and other system components.				X
Electrical systems	Clean all electrical terminals. Check electronic controls and replace any defective parts.				X
Hydraulic and pneumatic valves	Check operation and repair as necessary.				X
Flue gases	Make adjustments to ensure optimal flue gas composition. Record composition, firing position, and temperature.				X
Eddy current test	As required, conduct eddy current test to assess tube wall thickness.				X

8.07 Water treatment

Depending on whether the source of water is surface or underground water, the water treatment plant operations involves raw water aeration, coagulation, filtration in the coarse, fine and carbon filters. The carbon filter is required if the water is chlorinated. Other standard units that may be included are aerators, lime dosing unit, and chlorinator. However, if the water is only for rice processing and not for drinking then only the filtration and coagulation treatments may be sufficient.

a. Principles of Water treatment

Natural waters contain dissolved minerals. Water containing Ca^{2+} and Mg^{2+} ions are usually called **hard water.** Water treatment is a process of making water suitable for its application or returning its natural state. All water treatments involve the removal of solids, bacteria, algae, plants, inorganic compounds, and organic compounds. A standard water treatment involves raw water aeration, removal of solids by filtration and sediment, Coagulation, flocculation/sedimentation and hardness removal and disinfection (Chlorination/Ozone treatment).

b. Aeration

Bringing air into intimate contact with water for the purpose of exchanging certain components between the two phases is called aeration. Oxygenation is one of the purposes of aeration to oxidize soluble ions to insoluble precipitate out of solution for filtering. The process also removes volatile organic substances, hydrogen sulfide, ammonia, and volatile organic compounds

c. Filtration

Filtration is the process of removing solids from a fluid by passing it through a porous medium. The filter media are artificial membranes, nets, sand filter, and high technological filter systems. The choice of filters depends on the required filtering speed and the purity requirement. The flow required for filtration can be achieved using gravity or pressure. In pressure filtration, one side of the filter medium is at higher pressure than that of the other so that the filter plane has a pressure drop.

The process of removing the clogged portion of the filter bed by reversing the flow through the bed and washing out the solid is called **back washing**. During this process, the solid must be removed out of the system, but otherwise the filters must be either replaced or taken out of service to be cleaned.

d. Water softening:

Hardness in water is due to presence of dissolved ions like Ca^{2+}, Mg^{2+}, Na^{+}, HCO^{3-}, $SO4^{2-}$, $SiO^{4,}$ CL^{-} etc to give temporary or permanent hardness. The HCO^{3-} is the major cause of temporary hardness and if not removed is converted to CO^{3-} on the heating surfaces of flu-tubes and boiler drums causing local heating and pitting (corrosion) and eventual loss of tube. For this reason, water is normally treated to remove permanent and temporal hardness. Lime-soda softening is the removal of temporary hardness by adding a calculated amount of hydrated lime. While sodium carbonate is added to remove Mg^{2+} responsible for permanent hardness.

Thus, lime-soda softening is effective if both the temporary and total hardness have been determined. The sodium ion will remain in the water after the treatment. The pH of the water is also rather high depending on the amount of lime and sodium carbonates used.

e. Water treatment machinery/Maintenance

Basically, maintenance of water treatment plant involve backwashing of the filter tanks, instrument, pump, valves, lime dosing unit and water pressure increasing system maintenance. In this section the maintenance of pumps shall be treated.

8.08 Types of Pumps

The family of pumps comprises a large number of types based on application and capabilities. The two major groups of pumps are dynamic and positive displacement.

Dynamic Pumps are Centrifugal Pumps and include **Radial flow**—a centrifugal pump in which the pressure is developed wholly by centrifugal force. **Mixed flow**—a centrifugal pump in which the pressure is developed partly by centrifugal force and partly by the lift of the vanes of the impeller on the liquid. **Axial flow**—a centrifugal pump in which the pressure is developed by the propelling or lifting action of the vanes of the impeller on the liquid.

a. Positive Displacement Pump

A positive displacement pump has an expanding cavity on the suction side of the pump and a decreasing cavity on the discharge side. Liquid is allowed to flow into the pump as the cavity on the suction side expands and the liquid is forced out of the discharge as the cavity collapses. This

principle applies to all types of positive displacement pumps whether the pump is a rotary lobe, gear within a gear, piston, diaphragm, screw, progressing cavity, etc.
A positive displacement pump, unlike a centrifugal pump, will produce the same flow at a given rpm no matter what the discharge pressure is. A positive displacement pump cannot be operated against a closed valve on the discharge side of the pump, i.e., it does not have a shut-off head like a centrifugal pump does. If a positive displacement pump is allowed to operate against a closed discharge valve, it will continue to produce flow which will increase the pressure in the discharge line until either the line bursts or the pump is severely damaged or both.

b. Pump Maintenance

The importance of pumps to the daily operation of processes necessitates a proactive maintenance program. Most pump maintenance activities center on checking packing and mechanical seals for leakage, performing preventive or predictive maintenance activities on bearings, assuring proper alignment, and validating proper motor condition and function.

c. Pump Safety Issues

TABLE 9. General Safety Requirements for Pumps

Safety Apparel	Wear: • Insulated work gloves when handling hot bearings or using bearing heater. • Heavy work gloves when handling parts with sharp edges, especially impellers. • Safety glasses (with side shields) for eye protection when working in a machine shop area. • Steel-toed shoes for foot protection when handling parts, heavy tools, etc.

Safe Operating Procedures	Use:
	• Coupling guards: Never operate a pump without coupling guard properly installed.
	• Flanged connections:
	  o Never force piping to make connection with pump.
	  o Insure proper size, material, and numbers of fasteners are installed.
	  o Beware of corroded fasteners
	• When operating pump:
	  o Do not operate below minimum rated flow, or with suction or discharge valves closed.
	  o Do not open vent or drain valves closed or remove plugs while system is pressurized.
	  o Beware of corroded fasteners

Maintenance and Safety	• Always lock out power • Ensure pump is isolated from system and pressure is relieved before any disassembly of pump, removal of plugs, or when disconnecting piping. • Pump and components are heavy. Failure to properly lift and support equipment could result in serious injury. • Observe proper decontamination procedures. Know and follow company safety regulations. Never apply heat to remove impeller.

d. Basic Measures to Improve Pump Efficiency

1. Shut down unnecessary pumps.
2. Restore internal clearances if performance has changed.
3. Trim or change impellers if head is larger than necessary.
4. Control by throttle instead of running wide-open or bypassing flow.
5. Replace oversized pumps.
6. Use multiple pumps instead of one large one.

e. Compressed air supply equipment

This equipment is situated in the control room. The compressed air is used in process equipment and in cleaning sieves. The air receiver working pressure is $12kg/cm^2$. The compressed air handling equipment consists of two single stage rotary and one single stage 3-cylinder reciprocating compressor.

f. Housekeeping in compressor room. Housekeeping in the compressed air supply room is poor. The room is a makeshift store for unusable parts. Bucket conveyor parts, belt etc were seen parked in corners of the room. Ventilation is poor as the only room for ventilation was blocked by received rice paddies. The compressor cables are not in cable trays making it possible for personnel to trip over.

g. Compressor situation: at the time of visit the reciprocating compressor panels were open exposing the compressor control part, there was no guard to protect the reciprocating compressor`s drive assembly thus making the unit unsafe for personnel. See figure below.

Fig 29 Unguarded drive of a reciprocating compressor

h. Care of compressor: No routine maintenance schedule card was seen in any of the machines in this room. This indicates that the manufacturer's maintenance schedule is not followed. There was also no schedule for cleaning of strainers and air line.

i. Types of Air Compressors

There are two general types of air compressors—positive displacement and centrifugal.

j. Positive Displacement Compressors

Rotary screw compressor—The main element of the rotary screw compressor is made up of two close clearance helical-lobe rotors that turn in synchronous mesh. As the rotors revolve, the gas is forced into a decreasing inter-lobe cavity until it reaches the discharge port. In lubricated units, the male rotor drives the female and oil is injected into the cylinder serving as both a lubricant and coolant, and also as an oil seal to reduce back slippage. On non-lubricated types, timing gears are used to drive the rotors and multistage is necessary to prevent gas temperatures from going too high.

Reciprocating compressor—A reciprocating compressor is made up of a cylinder and a piston. Compression is accomplished by the change in volume as the piston moves toward the "top" end of the cylinder. This compression may be oil-lubricated or, in some cases, it may require little or no lubrication in the cylinder.

The cylinder in the reciprocating machines may be air cooled or water cooled. Water cooling is used on the larger units. This cooling action is very important to increase compressor life and to keep maintenance and repairs low.

Multiple stage compressors have a minimum of two pistons. The first compresses the gas to an intermediate pressure. After the first stage compression, intercooling of the gas occurs before entering the second stage. Two stage units allow for more efficient and cooler operating levels, which increase compressor life.

k. Centrifugal Compressor

The compression action is accomplished when the gas enters the center of rotation and is accelerated as it flows in an outward direction. This gas velocity is then transferred into a pressure rise. Part of the pressure rise occurs in the rotor and part in a stationary element called the diffuser. The rotating element can either have forward curved blades, radial blades, or backward blades.

The centrifugal compressor will usually have more than one stage of compression with intercooling between each stage. One of the drawbacks of this machine is its inability to deliver part-load flow at overall efficiencies as high as other types of compressors. Many people consider the centrifugal machine a base-load machine.

l. Key Components of Compressors

Table 10. Components of a reciprocating compressor

Component	Description
Cylinder	Chamber where the compression process takes place by the change in its volume as the piston moves up and down.
Piston	Component located inside the cylinder directly responsible for the compression of air.
Crankshaft	Converts rotational motion generated by the motor to unidirectional motion for the piston.

TABLE11. Rotary Screw Compressor

Component **Description**

Helical-lobe rotors	The main elements of this type of compressor where two close clearance helical-lobe rotors turn in synchronous mesh. As the rotors revolve, the gas is forced into a decreasing inter-lobe cavity until it reaches the discharge port.

Centrifugal Air Compressor

Component	**Description**
Rotating impeller	Imparts velocity to the air, which is converted to pressure.

Air Compressor Safety Issues

All components of compressed air systems should be inspected regularly by qualified and trained employees. Maintenance superintendents should check with government and/or insurance companies to determine if they require their own inspection of this equipment. Operators need to be aware of the following general safety requirements for compressed air.

m. Air Recievers

- The maximum allowable working pressures of air receivers should never be exceeded, except when being tested. Only hydrostatically tested and approved tanks shall be used as air receivers.
- Each air receiver shall be equipped with at least one pressure gauge and safety valve of the proper design.
- A safety (spring loaded) release valve shall be installed to prevent the receiver from exceeding the maximum allowable working pressure.

n. Air Distribution Lines

- Air lines should be made of high quality materials and fitted with secure connections.
- Hoses should be checked to make sure they are properly connected to pipe outlets before use.
- Air lines should be inspected frequently for defects. Any defective equipment should be repaired or replaced immediately.
- Compressed air lines should be identified as to maximum working pressures (psi) by tagging or marking pipeline outlets.

o. Pressure Regulation Devices

- Valves, gauges, and other regulating devices should be installed on compressor equipment in such a way that they cannot be made inoperative.
- Air tank safety valves should be set no less than 15 psi or 10% (whichever is greater) above the operating pressure of the compressor. They should never be set higher than the maximum allowable working pressure of the air receiver.

p. Air Compressor Operation

- Air compressor equipment should be operated only by authorized and trained personnel.
- The air intake should be from a clean, outside, fresh air source. Screens or filters can be used to clean the air.
- Air compressors should never be operated at speeds faster than the manufacturer's recommendations.

- Moving parts, such as compressor flywheels, pulleys, and belts that could be hazardous should be effectively guarded.

q. Air Compressor Maintenance

Maintenance of your compressed air system is of great importance yet it is often left undone or half done. Neglect of an air system will ultimately "poison7" the entire downstream air system and cause many problems. Clean, dry air supplies start at the air compressor package. The small amount of time you spend maintaining the system is well worth the effort.

r. General Requirements for a Safe and Efficient Air Compressor

- Always turn power off before servicing.
- Monitor compressor oil and oil cleanliness:
  - Change the oil according to manufacturer's recommendations.
  - Use a high-quality oil and keep the level where it's supposed to be.
  - Sample the oil every month.
- Monitor condensate control:
  - Drain fluid traps regularly or automatically.
  - Drain receiving tanks regularly or automatically.
  - Service air-drying systems according to manufacturer's recommendations.
- Keep air inlet filters clean.
- Keep motor belts tight.
- Minimize system leaks.

Table 12 Air Compressor Maintenance Checklist

Description	Comment	Maintenance Frequency			
		Daily	Weekly	Monthly	Annually
Compressor use	Turn off unnecessary compressors	X			
Overall visual inspection	Complete overall visual inspection to be sure all equipment is operating and that safety systems are in place.	X			
Leakage Assessment	Look for and report any system leakages.	X			
Compressor ventilation	Make sure proper ventilation is available for compressor and inlet.	X			
Compressor lubricant	Note level, color, and pressure. Compare with trended values.	X			
Condensate drain	Drain condensate from tank, legs, and traps.	X			
Operating temperature	Verify operating temperature is per manufacturer's specification.	X			
Pressure relief valves	Verify all pressure relief valves are functioning properly.		X		
Check belt tension	Check belt tension and alignment for proper settings.		X		
Intake filter pads	Clean or replace intake filter pads as necessary.		X		
Air-consuming device check	All air-consuming devices need to be inspected on a regular basis for leakage. Leakage typically occurs in:		X		

	• Worn, cracked, or frayed hoses • Sticking air valves • Cylinder packing				
Drain traps	Clean out debris and check operation.		X		
Motor bearings	Lubricate motor bearings to manufacturer's specification.			X	
System oil	Depending on use and compressor size, develop periodic oil sampling to monitor moisture, particulate levels, and other contamination. Replace oil as required.			X	
Couplings	Inspect all couplings for proper function and alignment.				X
Shaft seals	Check all seals for leakage or wear.				X
Air line filters	Replace particulate and lubricant removal elements when pressure drop exceeds 2-3 psid.				X
Check mountings	Check and secure all compressor mountings.				X

SECTION 9

CONSIDERATIONS IN SHELF-LIFE AND STORAGE OF PROCESSED RICE

9.01 Rice Storage and its Conditions

The major parameter that could cause problem to stored rice is moisture. If the moisture content is high then the product is bound to be infected by mould during storage thus reducing the shelf life. It is important to maintain the moisture content below the level that constitutes risk to the product. A moisture content of 12 - 13% is recommended.

The control of moisture starts from the paddy. Before milling the moisture content should be determined, and should be within the recommended specification. However, if it is above the recommended limit there is need to dry the grains further to reduce the moisture content to the recommended levels. After the parboiling process the subsequent drying operation must be controlled to ensure that the moisture content is between 12 – 14% to avoid spoilage while the product is in the distribution.

Another parameter that could affect processed rice during storage is the packaging material. Appropriate packaging materials that can protect the product from contamination. In Liberia parboiled rice is mostly sold in woven plastic bags. Considering that this type of packaging is not airtight, it is important that the products be transported and stored in such a way that moisture migration into the grains is minimized. The product should also be stored at the appropriate conditions of temperature and relative humidity. They should be packed on top of pallets and away from the walls to prevent moisture migration. The need to adequately control moisture content of the products is due to the role water plays in the storage of grains.

Water is an important constituent of all raw foods and an important structural constituent of processed foods. Water in foodstuffs is measured in terms of moisture content and may be expressed on wet or dry basis as a percentage. Moisture content of foods directly affects their shelf stability. Moisture content of foods determines the type of microorganisms that grow and cause spoilage of foods. Hence for stored rice, increase in moisture will increase the chances of growth of microorganisms especially the moulds. A moisture content of about 13% is recommended. It is also important that the relative humidity is monitored. The relative humidity suitable for the storage of rice is about 65%.

Moisture effects on microbial growth are less complicated than its effects on chemical reactions in foods. It determines the lower limits of chemical activities going on in foods. Some of the major roles of water in foods are:

a. It acts as solvent for reactants and products. Its property as universal solvent is unparallel compared to other solvents.
b. It is a reactant in many biochemical and chemical reactions involving hydrolysis.
c. It is a product of many condensation reactions in foods.
d. It is a modifier of catalytic or inhibitory activities of other substances.
e. It plays some parts in lipid oxidation and in reactions between lipids and proteins.
f. It also contributes to enzymatic browning in foods.

Many food preservation processes that work on the principles of moisture removal lower the available moisture for microorganisms which may occur in foods during storage. They also lower the available moisture which could have been used for chemical and physical processes in foods.

9.02 Handling and Use of Grain Protection Products

Methyl bromide and phosphine are major fumigants commonly in use on a world-wide scale. The advantages and disadvantages of these two fumigants are summarised in Table86 below. In addition, it should be noted that both phosphine and methyl bromide are currently regarded as gases with potential negative impact on the atmospheric environment. Constraints on their use are likely to increase and requirements for careful, responsible use, with more regular monitoring of application rates, are likely to be more strictly enforced.

Table 13. Advantages and Disadvantages of Phosphine and Methyl Bromide as Fumigants

Phosphine	Methyl bromide
Easy to transport	Refillable cylinders are expensive to transport
Easy to apply	Difficult to apply, requiring special equipment and skill
Good penetration and distribution	Distribution rather poor
Taint, residues and loss of viability in treated seeds are generally negligible	Sorption occurs and may cause taint, bromide residues and loss of viability in treated seeds

Slow acting, particularly at low temperatures and humidities	Rapidly toxic and widely effective even at lower temperatures
Flammable: spontaneously explosive ignition can occur in some circumstances	Non-flammable
High acute mammalian toxicity but low chronic toxicity	Dangerous acute and chronic poison with delayed symptoms
Fairly easy to detect	Very easy to detect
Rapidly lost by leakage unless fumigation space is well sealed and gas tight soon after application	Needs very good seeing before application

9.03 Post Harvest/Storage Pest Management

a. Pest management philosophy

Insects are considered pests because of the socioeconomic and medical threat they pose to man and his property. Biologically, an insect is a pest because its population density and/or damage level exceeds a pre established or conceptualized threshold called the economic injury level (EIL), below which the insect does not constitute an economic threat. This is defined as the lowest population or damage level capable of causing economic impact. If the population of an organism exceeds the EIL, the organism becomes a pest.

b. Physical control measures for pests

This will involve the use of traps or cages for rats, birds and other vertebrates and sticky tape, swats or lures for flies and other insects. These days electronic devices are available which are mounted to attract and kill insects. However, this type of control only eliminates a very small percentage of rice pests.

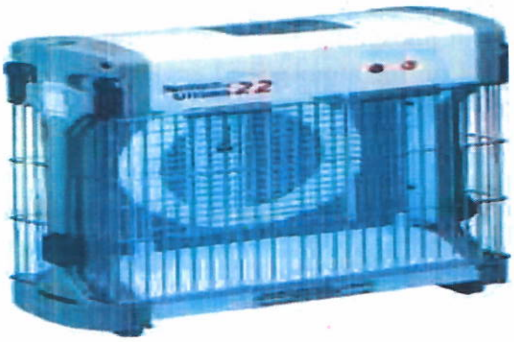

Fig. 30. A Typical Electric Fly Killer

c. Chemical Control

This involves the use of fumigants. Fumigants are toxic gases used to disinfest a commodity in an air tight enclosure. Fumigation enclosures should be sufficiently airtight for the gas to remain in the commodity for long enough to kill all stages of the insects present in or amongst the grains. A gas or vapor that does not have the ability to penetrate the grain is not, strictly speaking, a true fumigant.

The purpose of a fumigation is thus to obtain a more-or-less immediate disinfestations of the commodity and the space enclosing it. Fumigation is the only chemical treatment that can achieve this effect and this relative immediacy of disinfestation, together with its completeness if done properly, is the main advantages of this particular chemical control technique. Its main disadvantages are that the treatment confers no residual protection against reinfestation, once the commodity is again exposed, and the fact that the most effective fumigants are all highly toxic to humans and other non-target organisms. The precautions required to ensure the safe use of fumigants are, necessarily, much more stringent than those required to ensure the safe use of most other insecticides.

Some fumigants that are no longer widely approved for use on stored grain due to restrictions placed upon their use in some countries include carbon tetrachloride and ethylene dibromide, both of which are low-volatility fumigants with recently identified chronic user hazards. Another low-volatility halogenated hydrocarbon, ethylene dichloride, is not so clearly implicated but is less commonly available than it was formerly. The desirable properties of a grain fumigant, notably efficient penetration of the commodity, toxicity to target insects and lack of harmful residues, make it unlikely that new chemical compounds will become available as fumigants . Carbon dioxide can be used as a conventional fumigant but low toxicity to insects and the consequent high degree of air tightness necessary for effective insect control makes it unlikely that this gas will find widespread use except in controlled atmosphere (CA) storage systems and small containers.

Phosphine, because of its availability in solid formulations of metal phosphides which are relatively easy to apply, compared with the pressurised gas fumigant methyl bromide, has become the most popular and widely used fumigant in most tropical countries. Methyl bromide, which is in some ways more versatile, retains its place as the fumigant of choice wherever circumstances do not easily accommodate the protracted fumigation period, of several days duration, that is required for the effective use of phosphine.

d. Biological Control

Conventional biological control techniques for possible application in stored-grain pest control include control by the use of predators, parasites, insect diseases and sterile males, the use of pheromones for pest monitoring, mating disruption or enhanced mass trapping, and the use of resistant crop varieties. Irradiation techniques and controlled atmosphere storage are included here, although they may also be regarded respectively as physical and chemical techniques, because their use depends upon radical interference with biological systems or processes.

Controlled atmosphere (CA) storage has become an important addition to the available options for stored-grain pest control.

e. Use of Traditional Grain Preservatives

The occasional use of abrasive mineral dusts, natural desiccants like wood ash and various plant materials with repellent or insecticidal properties is well known and documented. Recent interest in such materials, intensified by a common concern to reduce, if possible, the general dependence upon synthetic pesticides by promoting the use of alternative materials, has produced a flood of information on experiments that have tested many plant materials. Regrettably, much of the published information is of limited value because practical aspects, including availability and acceptability for use as food grain protectants, are generally overlooked.

f. Integrated control measures for pests

This will involve the combination of the various control measures available. This means that rice grains should be stored in the appropriate storage facilities with the application of the necessary insecticides. This however, will depend on a number of factors such as cost, but they should be balanced to obtain the best result. Also there is the need for a time-based fumigation of the entire plant. This will help prevent the growth and proliferation of pests in and around the factory site.

g. Storage Pests found in rice

A multitude of insects is adapted to the relatively dry environment of stored rice. Rice grain infesting insects can develop at grain moistures as low as 8%. They not only consume large quantities of grain but they reduce the value by altering the perception of quality. Insect activity also changes the environment in the bin to make it more susceptible to fungal growth. Principal insects infesting stored rice include the rice weevil *(Sitophilus oryzae)*, the lesser grain borer *(Rhyzopertha dominica)*, rust-red grain beetle *(Cryptolestes ferrugineus)* and the confused flour beetle *(Tribolium confusum)*.

g-1. Rice weevils may have long snouts (figs 9 and 10) with chewing mouthparts at the end. They are dark brown and about an eighth of an inch in length. Egg, larval, and pupae stages are spent inside the rice kernel. Generally there is only one larva per seed. To the naked eye there is little evidence of damage until the adult emerges from the hollow seed. The rice weevil is capable of flight but can also be transported in infested lots of grain.

g-2. The lesser grain borer can be one of the most damaging insects found in stored rice. Its body is cylindrical, about 1/8 inch long, with a distinctive helmet-like hood over the head. Larvae develop inside the rice kernel and are therefore invisible during most of their life cycle. Grain dust and a sweet must odor characterize the presence of the lesser grain borer. Accumulated and compacted dust can lead to poor aeration in the bin and a greater potential for grain spoilage.

Control of storage insects depends on cleaning of storage facilities between harvests, carefully controlling the temperature and humidity, and the use of recommended control measures.

SECTION 10

OCCUPATIONAL HEALTH ISSUES AND MANUFACTURING PRACTICES IN THE RICE PROCESSING INDUSTRY

10.01 Hazard Analysis Critical Control Points (HACCP) in Equipment Maintenance

There should be a food safety progamme developed for the entire plant. Management and staff should implement the Hazard Analysis and Critical Control Point (HACCP). The objectives of HACCP plan include promoting current good manufacturing practices (cGMPs) and the associated HACCP system through the use of the Codex General Principles of Food Hygiene and other Codex codes of hygienic practice. This is to enhance the role of science and risk analysis in the system and the development of HACCP systems for determining equivalence of food safety control programmes.

There is a worldwide interest in implementation of the HACCP system by the food industry and food control regulatory agencies. In many countries, application of the HACCP system to imported foods may also become mandatory. The HACCP system can be applied throughout the food chain from the primary producer to the final consumer. Besides enhancing food safety, other benefits in applying HACCP include more effective use of resources and more timely response to food safety problems. In addition, the application of the HACCP system can aid inspection by food regulatory and control authorities and promote international trade by increasing buyer confidence in food safety.

A HACCP plan is specific to a particular food and processing application. It is capable of accommodating change, such as advances in equipment design, processing procedures or technological developments.

The successful application of HACCP requires the full commitment and involvement of management and the workforce. It also requires a team approach. The application of the HACCP system is compatible with the implementation of quality management systems, such as the International Organization for Standardization's ISO 9000 series, and is the system of choice in the management of food safety within such systems.

The HACCP system as applied for food safety management uses the approach of controlling critical points in food handling to prevent food safety problems. It is a system for identifying specific hazards and preventive measures for their control. The system comprises seven principles:

· ***Principle 1.*** Identify the potential hazards associated with food production at all stages, from growth, processing, manufacture and distribution to the point of consumption. Assess the likelihood of occurrence of the hazards (risk assessment) and identify preventive measures for their control (risk management).

· ***Principle 2.*** Determine the points, procedures and operational steps that can be controlled to eliminate the hazards or minimize their likelihood of occurrence; these are the critical control points (CCPs), A "step" means any stage in food production and/or manufacture including receipt and/or production of raw materials, harvesting, transport, formulation, processing, storage, etc.

· ***Principle 3.*** Establish critical limits which must be met to ensure that the CCPs are under control.

· ***Principle 4.*** Establish a system to monitor control of CCPs by scheduled testing or observations.

· ***Principle 5.*** Establish the corrective action to be taken when monitoring indicates that a particular CCP is not under control.

· ***Principle 6.*** Establish procedures for verification which include supplementary tests and procedures to confirm that the HACCP system is working effectively.

· ***Principle 7.*** Establish documentation concerning all procedures and records appropriate to these principles and their application.

10.02 Occupational Health and Good Manufacturing Practices

Rice has continued to be a source of great satisfaction for many - providing a variety of delicacies, occupational involvements and income for the Liberian population. The need to improve on these levels of satisfaction for the future has necessitated the discussion on occupational health issues that may have hindered our wellbeing and profits in many ways

Health as fully captured by the World Health Organization (WHO) is "a state of complete physical, mental and social wellbeing and not only the absence of disease and infirmities". Since the most critical desire for any productive organization in business- such as in rice industry - is to make profit - it is therefore in her interest to *promote, preserve* and *protect* the health of its human resource base - the very essence of her survival and growth. Indeed the health of staff is particularly vital for a training of this nature. The purpose of occupational health is summarized by the First Joint WHO/ILO (International Labour Organization) Committee in 1950 in the followings words:

"Occupational Health should aim at the promotion and maintenance of the highest degree of physical, mental and social well-being of workers in all occupations; the prevention among workers from ill health caused by their working conditions; the protection of workers in their employment from risks resulting from factors adverse to health, the placing and maintenance of the worker in an occupational environment suited to his physiological disposition and to ensure the adaptation of work to man and each man to his job."

These mandates cover all staff including workmen, manager, director, clients and chief executives with no exception. The followings are the recommended organizational structure of Occupational Health services in any location: See Table 14

Table 14. Forms of Occupational Health Service

Scale of Industry	Number of Employees	Kind of services
Small-scale	50 or less	-First aid -use of Government /Private/Mission -Hospitals/Clinics and rural health services.
Medium-scale	51 and 1000workers	-same as for small industries or group -occupational health service
Large-scale	1000 plus workers	-Independent well equipped -Hospital/clinic - having preventive and -local population where government -health service are non-existent

The most basic tool to safeguard health in a workforce is FIRST AID. We shall briefly reflect on its importance.

10.03 First Aid Treatment

The most important treatment measure carried out in any industry is first aid. This is essential because it is prompt and thus reduces the amount of suffering of injured worker. It also reduces the severity of the injury by the time of arrival at the hospital/clinic. Being able to apply a tourniquet to a bleeding wound or stabilizing a fractured bone not only gives a measure of relief but also reduces the possibility of further damage. With good first aid, a definitive "cure" can be effected on the spot for such a condition as dislocation of the shoulder.

First Aid workers should be trained from among the regular staff with the help of NGOs and similar organizations or the Emergency/casualty unit of well established hospitals. Trainings should embody general first aid measures for dealing with haemorrhage, shock etc. When there are special risks such as chemical injuries to the eyes or other parts of the body, it becomes necessary to train the volunteer workers in dealing with such emergencies. As much as possible senior management such as foremen and sectional managers should be familiar with first aid.

10.04 Health Management Issues in the Processing Floor

The environment in which food processing is conducted is an important factor in ensuring the health of the workers. It is important that the buildings provide a comfortable and pleasant working environment conducive for good hygienic practices.

On the processing floor, the health of the worker is considered seriously. The processing area should be well lit, well ventilated and have sufficient space for personnel and machines. The size is also important to maintain the necessary separation between processes that could give rise to cross-contamination. Features such as control of temperature and relative humidity and a positive pressure of filtered air may be required in some process areas for the benefit of both personnel and product. Workers need to work at temperatures that will reduce sweating/perspiration. Workers who have been observed to be ill should not be allowed into processing areas so that such illnesses are not transferred to others.

In processing areas, floors should be made of durable materials which are impervious, non-slip, washable and free from cracks or crevices that may habour microorganisms that could be transferred to the food or to the workers. A slippery floor would endanger a worker who is likely to fall and injure him/herself. Proper washing and disinfection of the processing areas will prevent growth and multiplication of microorganisms that could infect workers and also contaminate the product.

Some measures could help in reducing risk of microbial infection of staff in the processing areas. These include; toilets should not open directly on to food-processing areas and must be provided with hand-washing facilities supplied with hot water, soap and hand-drying facilities. Also never attempt unsafe practices in the processing floor. Also moving parts of machines should be properly covered so that they do not constitute risk to staff.

10.05 Environmental Considerations in Rice Milling and Processing

Perhaps one of the best claims of any industry to viability is its ability to successfully manage its business as well as maintain a cordial relationship with its host community. No place is more vital for emphasis than how it manages the waste generated from its production process. The rice processing operations are a part of our environment and are often major generators of wastes. Since the existing environment is shared by the processors, consumers, other sectors of the economy and the population at large. The need to ensure the preservation of the environment in a natural and ecologically balanced manner cannot be over emphasized. Industrial wastes are a major source of environmental pollution that adversely affects the ecosystem.

The impacts of the food processing industries such as rice millers on - land use and land capability, noise and vibration, environmentally sensitive areas and visual quality - were identified to include: displacement of agricultural production, loss of forestry and pasture lands; cracks on buildings near or adjacent to the industries due to vibrations from heavy machines; noise pollution from processing machines leading to hearing loss/impairment; increased commercial and social activities and distortion of visual content and coherence. The effect of a rice processing industry on the host communities can be summarized in the following subtitles:

1. **Land Use and Land Capability:** The removal of vegetal cover due to site preparation and construction leads to loss of pasture land. This will have a negative effect on sedentary farmers. As a result the agricultural value of the land will depreciate and out-migration of farmers to seek alternative sites could occur. Other effects include: the amount and intensity of surface-water runoff could increase leading to erosion, and sedimentation.

2. **Noise and Vibration:** Noise pollution represents the exposure of people or animals to levels of sound that are annoying, stressful, or damaging to the ears. Noise generated by Rice mills could be as high as 60 – 115dB (acceptable level is 85 dB or less). Before the establishment of the plant, the area could have been classified as being very quiet and of the order of 20dB on the decibel scale. The most significant health problem caused by noise pollution is hearing loss. This is because any noise appreciably louder than talking can damage the delicate hair cells in the cochlea, the structure in the inner ear that converts sound waves into auditory nerve signals.

3. **Environmentally Sensitive Areas:** The location of a food industry such as a rice mill could cause considerable dislocation to some original inhabitants such as the displacement of farmers and their families. The loss of wetlands (which protected plants and animal species) leads to displacement of fishermen and their families in some instances. Plants and animal species could also be lost due to the removal of vegetative cover. Land filling and waste discharge can cause reduced yield of marine animals. The attendant loss of their means of livelihood causes serious agitation by the farmers, fishermen and their families.

4. **Visual Quality:** This implies the visual amenity or aesthetics of the industrial location. Food industrial plant also distort and impair the visual coherence and scenic beauty of the surrounding area by natural vegetation. Before the location of a plant, the area could have been described as serene and harmonious. The area becomes disfigured due to enhanced commercial and social activities, high rise buildings and emission/dispersion of dusts and exhaust gases into the atmosphere. The environment becomes disfigured due to enhanced commercial and social activities: noise from trucks conveying raw materials and finished products as well as the emission and dispersion of gaseous air pollutants and dusts. The effects of dusts and other gaseous deposits on vegetation include discolouration of green plants, reduction in rate of transpiration and decreased photosynthetic activity and hence yield. It also has adverse effects on pasture, rangeland and grazing animals. This could force pastoral farmers to look for grazing sites elsewhere.

5. **Deforestation:** In the drive to satisfy the fuelwood requirements of industrial activities such as small scale rice processing, agricultural lands could be stripped bare of vegetative cover. This places a heavy burden on the environment and on the resource base. The scramble for charcoal has resulted in massive destruction of many wood resources in parts of Liberia. Considerable wood charcoal fuel is mostly consumed for household cooking and industrial activities. Thus apart from the massive deforestation due to the establishment of a rice mill, a substantial part of energy for rice milling may be derived from wood fuel. Although large millers also use husk as fuel, the over-dependence on wood fuel for energy is chiefly because of its relatively low prices and easy accessibility.

Fig. 31 Stacks of Charcoal A Product of Deforestation

10.06 General Purpose good manufacturing practices (GMP), use of overalls and personal protective gear

It is defined as those procedures in a food processing plant which consistently yield products of acceptable microbiological quality suitably monitored by laboratory evaluation.

GMP will include all steps taken to make sure a good and acceptable product with consistent quality is produced. These steps will include the following;

1. Monitoring raw materials as they come into the factory; source of raw materials, quality of raw materials i.e. whether contaminated with other materials, damaged or attacked by pests or they show signs of contamination by microorganisms.
2. Handling and storage of raw materials; this will include whether they are stored under the appropriate conditions such as temperature, relative humidity and avoidance of cross-contamination.

The sanitation in a food processing plant is to assure that the food product which the company manufactures is wholesome and safe to eat. This usually means that the food does not contain, among other potential undesirable substances, any biological toxins, chemical toxicants, environmental contaminants, or extraneous substances.

Every manufacturing company, food or otherwise, has a master schedule of cleaning. Obviously, food particles attract rodents and other undesirable creatures, and their cleaning or removal is of utmost importance to the plant operation. A cleaning schedule essentially has the following components:

a. Coverage: Rooms, storage areas, toilets, offices, freezers, walls, ceilings, and so on.

b. Frequency: Each area requires a different frequency of cleaning, days (1, 2, 3, 4, etc), weekly, and so on.

A cleaning schedule is meaningful only if the methods of cleaning are appropriate and the schedule is enforced or implemented. Also, the frequency of cleaning must be carefully evaluated in conjunction with the methods of cleaning. This is because a process of cleaning may increase the dust load in the air, which may in turn contaminate other surface areas.

Some areas require frequent cleaning and others do not. A storage room with infrequent traffic may be cleaned once a week, while a storage room with frequent traffic may need to be cleaned once a day.

The areas to be cleaned should be evaluated with great care. Although most objects (e.g. Vats, holding tanks) are raised from the floor with a space for cleaning; it is still difficult to clean this part of the floor because the space is too narrow and hidden from view. Corners always pose a problem for cleaning. Special devices such as suction hoses are needed to keep them clean. These arė places where insects, rodents and other undesirable creatures will thrive. Bottoms of most equipment pose a problem in cleaning. Crawling on one's knees does not always solve the problem. Customized devices may be needed. Wet cleaning by hand or machine is acceptable. Modern technology has made available gel, foam, aerosols and special equipment. However, the water hose is still the method of choice in most food companies. Wet cleaning must take the following into consideration:

a. All materials that can absorb moisture, such as cardboard boxes, pallets and so on must be Removed.

b. After wet cleaning, the surfaces must be dried carefully.

c. A proper draining system should be in place and be maintained clean and free of debris around the openings.

10.07 General Purpose GMP

During processing, the processor should maintain high standards of personal hygiene. These are principally to avoid contamination of food with bacteria the food handler may habour as part of the body's flora e.g. Staphylococcus aureus and Salmonella typhi, or those they may bring in with them from the outside e.g. Listeria, Bacillus etc.

This then leads to the dos and don'ts associated with good personal hygiene. The dos are:

a. Wash your hands regularly throughout the day and especially;

- after going to the toilet
- on entering a food room and before handling food or equipment
- after handling raw foods
- after combing or touching the hair
- after eating , smoking, coughing or blowing the nose
- after handling waste food, refuse or chemicals.

b. Keep fingernails short and clean.

c. Cover any cuts, spots or boils with a water proof dressing.

d. Keep hair clean and covered to prevent hair/dandruff entering food.

e. Always wear clean protective clothing (including footwear) in food processing areas.
f. Always put on clean personal protective gears. These will include the use of masks to protect eyes, nose, mouth; use of hand gloves; use of ear mufflers; use of head gears such as helmets etc.
g. Thoroughly wash your body before and after the day's operations. Also make sure your work cloths are properly washed.

The don'ts are as follows;

- Do not smoke, chew gum, tobacco, fingernails or anything else
- Do not taste food or eat while in the processing floor
- Do not spit, sneeze or cough over food. In fact those showing signs of illness should not be allowed into the processing floor. He/she is a risk to fellow workers and can also contaminate the food material.
- Do not pick nose, ears or any other body site, so that you do not transfer microorganisms to food and to fellow workers.
- Do not wear jewelries when in the processing floor.
- Your protective wears should always be worn within the processing areas.
- Do not carry contaminated items such as dirty rags and tools in the pockets of personal clothing.

Correct cleaning procedures should be adopted to rid the processing areas of contaminants. It is recommended that the "clean-as-you-go" philosophy be adopted.

10.08 Occupational health related diseases.

Occupational health problems occur at work or because of the kind of work you do. These problems can include the following; cuts, broken bones, sprains and strains, or amputation, repetitive motion disorders, hearing problems caused by exposure to noise, vision problems or even blindness, illness caused by breathing, touching or ingesting unsafe substances, illness caused by exposure to radiation and exposure to microorganisms.

The main causes of occupational health related diseases in the food industries are as follows; musculoskeletal disorders, mainly comprising work-related upper limb disorders and back injuries; work-related stress, which can be caused by poor work organization; occupational asthma, caused by inhalation of bakery and grain dusts as well as flour, spices and wood dust. This is a potentially life-threatening disease; industrial bronchitis which is the inflammation of the large air ways of the lungs. This is caused by certain dusts, fumes, smoke or other substances. Symptoms include increased cough that brings up mucus, shortness of breath and wheezing; occupational dermatitis, arising from hand washing cleaners and some chemicals, contact with foodstuffs etc. It results in redness, scaling and blistering of the skin; rhinitis which is caused by irritant dusts such as bakery and grain dusts, spices, flour and seasonings. It results in the inflammation of the nasal mucus membrane; hypersensitivity pneumonitis, an inflammatory illness of the lungs caused by breathing foreign materials such as dust and mould spores. Symptoms include chills, cough, fever, malaise and shortness of breath; noise-induced hearing loss which results when noise levels exceed the acceptable levels (85 dB).

Fig32 A typical head gear with ear muffler attached

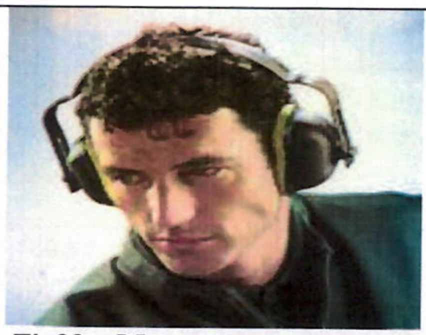

Fig33 Multi-position head band ear defender

Noise arises from various sections of the plant due to machinery etc. This effect however, is not immediately noticeable as it builds up gradually over time. There is some equipment that can be mounted or put in place to help detect noise levels. Their use is also encouraged. Simple ear plugs can also be used to reduce noise.

Fig 34 A typical noise meter

Fig 35 Ear plug

Musculo-skeletal disorders are the most prevalent of these diseases although others do occur frequently when the conditions responsible for them arise.

Good job safety and prevention practices can reduce your risk of these problems. Try to stay fit, reduce stress, set up your work area and use the right equipment and gear.
Occupational health problems occur in a rice processing industry may include the followings in Table 15. Good job safety and prevention practices can reduce your risk of these problems. Try to stay fit, reduce stress, set up your work area and use the right equipment and gear.

Table 15 Features of Occupational Health in Rice Processing Industries

Disorders	Symptoms	Causes	Treatment	Protective Gears
Musculo-skeletal	Work-related stress Back injuries	Wrong/ rigid posture	Consult Physician	Not Applicable
Work-related	Dizziness	Poor work	Flexible work	NA

stress	Tiredness	organization	schedule/structure	
Occupational Asthma	Shortness of breath	Inhalation of grain Dust/flour	Consult Physician	Respirator
Industrial Bronchitis	Inflamation of lungs Coughing with mucous	Dust/fumes/smoke Etc.	Consult Physician	Respirator
Occupational Dermatitis	Skin irritation blistering skin scaly/red skin	Chemical contact with skin/food stuff skin reactions	Consult Physician	Protective clothing
Rhinitis	Inflamation of the Nasal mucous membrane	Irritants like dust, grain dust/flour/cement etc.	Consult Physician	Respirator
Hyper sensitivity pnuemonitis	Inflammatory illness of the lungs/chills/cough/fever and shortness of breath	Breathing in of foreign materials like dust/moulds	Consult Physician	Respirator
Noise-induced hearing loss	Difficulty in picking sound	Working in a high noise environment	Consult Physician	Ear plug

10.09 Use of personal protective equipment (PPEs)

The worker in the processing floor should be provided with personal protective equipment so as to reduce the risk of injury to self, catching an infection or developing a disease condition while working in the establishment. This is because work-related causes of ill health can be more difficult to detect. These PPEs include the following; protective cloths to prevent toxic compounds such as agrochemicals from touching the skin, although the level of clothing depends on the harmful effects of the agrochemical and the way in which it is used.

Fig 36 A typical coverall for protection against chemicals

Fig 37 Fire resistant coverall

In practice, labeled information supplied with the agrochemical generally specifies the level of protection required. Other types of coveralls are available for protection from other types of accidents e.g. fire.

Masks and safety glasses prevent inhalation of dust particles. They also prevent such particles from entering the eyes and protecting the face from accidental splashes of dangerous liquids during opening or pouring from containers

Fig 38 goggles with strap to fasten the glasses

Such face shields should cover the whole forehead and face to a point below the jaw. Several types of respirators are in use. There are those that cover only the nose and mouth and those that cover the nose, mouth and eyes. Some examples are shown below;

Fig 39 Respiratory Protector

Fig 40 Clothing for hazardous dust protection. Note the nose mask.

Fig 41 Clothing for protection against chemical spills

Fig 42 Clothing for multi hazard protection. Note the boots and helmets

Good respirators are manufactured to comply with national standards in several countries. The user should, however, ensure that the respirator provides a good fit around the nose and mouth and that he or she has received sufficient information and training on correct use and maintenance. Also ear mufflers should be provided to prevent the effect of noise from machines from affecting the ear (see occupational health related diseases) as well as provision of helmets to prevent the head from injury.

Fig43 Safety helmets for industrial use

Gloves should also be provided to prevent them from touching materials especially chemicals, with their bare hands. They should be at least 0.4 mm thick while retaining flexibility for -simple manual tasks such as opening containers or changing nozzles. The type of glove for a particular operation will depend on the agrochemical and the length of time in contact. For example, gloves of wrist length may be required for conventional spraying of toxic pesticides, elbow length for handling granules, and shoulder length for dipping plants in pesticides. A pesticide formulation with organic solvents such as xylene will require a glove of much higher-quality material because of its capacity to penetrate protective garments.

Fig44 Flexible gloves for handling machines

Fig 45 Hand gloves for protection against chemicals

Fig46 Hand gloves for protection against mechanical injury

Fig 47 Hand gloves for protection against thermal injury

Safety boots should also be provided to prevent injury on the legs. Those that are normally recommended are those with metal shield at the toe region. It is also very important that a first aid unit is provided to take care of minor or even major health issues that may arise during processing. The workers should also be trained to handle emergency situations. There is also need to make provisions for emergency exits. Sufficient safety signs at different parts of the premises should be put in place.

Fig 48. Full face respirator and complete cover is vital before entry into a polluted and harzardous environment

Fig 48 A typical fire hydrant

Bibliography,

Biyi, Darmola (2005): "Government Policies and Competitiveness of Nigerian Rice Economy," Paper Presented at the Workshop on Rice Policy and Food Security in Sub-Saharan Africa Organized by WARDA, Cotonou, Republic of Benin, November 7-12, 2005.

Nwosu, C.S and B.C. Nnadozie (2009): *Element of Farm Management and Agricultural Production Economics,* 1st ed. Owerri, Nigeria, Springfield Publishers Ltd.

Odoemena, Benjamin; Ihedioha, Damian; Ibana, Simion and Okoli, Paul (2008). MakingRice Agribusiness Work in Sub-humid Tropics of Nigeria: The Commodity Value Chain Approach, *African Journal of Agricultural Research,* Vol.3 (11), Pp 779-786.

USAID (2009): Global Food Security Response: West Africa Rice Value Chain Analysis, microREPORT # 161 October, 2009.

Food Chain. Using solar heat to disinfest grain. No. 07 - November 1992 (ITDG, 1992, 20 p.

Hui, Y.H. 2004. Food Plant sanitation and quality assurance. In: Food Processing; principles and applications (Scott Smith, J. and Hui, Y.H. eds.). Blackwell Publishing, Oxford.p151-155.

Ihekoronye, A. I. and Ngoddy, P.O. (1985). "Integrated Food Science and Technology for the Tropics". Macmillan Publishers. London. Pp. 283-289.

Akpapunam M.A. (2005) Rice Processing by Products and waste Utilization. An invited paper presented at...Rice Quality www.knowledge bank .irri .org.

Alaka, I.C. (2005) Upgrading the Quality of Local Rice for Local and International Markets. An invited paper presented at the Annual General meeting of Nigerian Institute of Food Science and Technology (NIFST). Oct 11-13.

Araoullo, D.E., V. Depaduo, O.B and Graham, M (1978) Rice Post Harvest Technology. International Development Centre (IDRC) Ottawa Canada IDRC 053C.

Esmay, M., Soemanaget, E, and Philips, A.(1979) Rice Post Production Technology in the tropics. The Uni. Press of Hawai Honolulu pg140.

Garibaldi, F. (1984) Rice Parboiling FAO Agric Science Bull 56 Rome FAO pg73.

Ihedioha, Damian (2006): Towards Appropriate Pricing of Locally Processed Rice, Abakaliki, 13 – 17 May, 2006

Interface between Agriculture, Nutrition and Food Science (1984) Harvesting and Threshing operations Human Development Library Document Text.

Juliano, B.O (1993) Rice in Human Nutrition. Published by FAO and International Rice Research Institute Philippine

Juliano, B.O .(1998) Verietal Impact on rice quality cereal food world (43) 207-222.

Kent, N.L.(1984) Technology of Cereal and Introduction for Students of Food Science and Agriculture Third Ed. Pergamon Press.

Mutter, R.G. (2003) Concept of Rice Quality, Rice Quality Workshop.

Nkama, I. (2005) Modern Methods of Rice Processing. An invited paper presented at the Annual General Meeting NIFST Oct 11-13.

Osuji, C.M. (2006) Waste from Rice Industry, Utilization and economic value. Workshop in Rice Processing Packaging and Marketing Organized by Nigerian Institute of Food Science and Technology (NIFST) at Abakaliki Ebonyi State, Nigeria 13 – 17 May, 2006.

Sahay .k. M, Singh K.K Unit Operations of Agricultural processing, Publisher, Vikas publishing house PVT Ltd, 1994

Adams, M.R. and Moss, M.O. 1999. Food Microbiology. The Royal Society of Chemistry, Cambridge. p336-355.

www.hygienesuppliesdirect.com/ Accessed 30th Dec. 2016

www.rpsgroup.com/occupational-Health.aspx Accessed 30th Dec. 2016

www.inchem.org/document/pds/pv+46_eoliton Accessed 30th Dec. 2016

www.ipm.ucdavis.edu/PMG/selectnewpest.rice.html Accessed 30th Dec. 2016

http/agropedia.iitk.ac.in/?=content/integrated-pest-management-rice Accessed 30th Dec. 2016

www.financialexpress.com/news/assar-steel-plant-coverting-waste-into-wealth/353085 Accessed 30th December 2016