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Unit 2 – Topic 1

Paddy processing and rice milling, Milling machines

Rice is one of the most important staple foods in India, which is the second-largest producer of paddy in the world. In 2022, the paddy production was around 129 million metric tons. The paddy produced has to be processed to make it consumable in the form of rice grain.

Basic paddy processing involves cleaning it of external material, removing the husk, and polishing the rice. The whole process of paddy processing can be divided into 3 steps:

Procurement of Paddy

After the paddy is harvested, the farmers dry the grains to reduce the moisture from 25% to 14%. Then it is brought to the processing plant for quality check and storage. The quality parameters include:

When farmers bring their paddy to rice mills, several quality checks are typically conducted at the purchase point to assess the quality, grade, and value of the paddy. Here are some common quality checks:

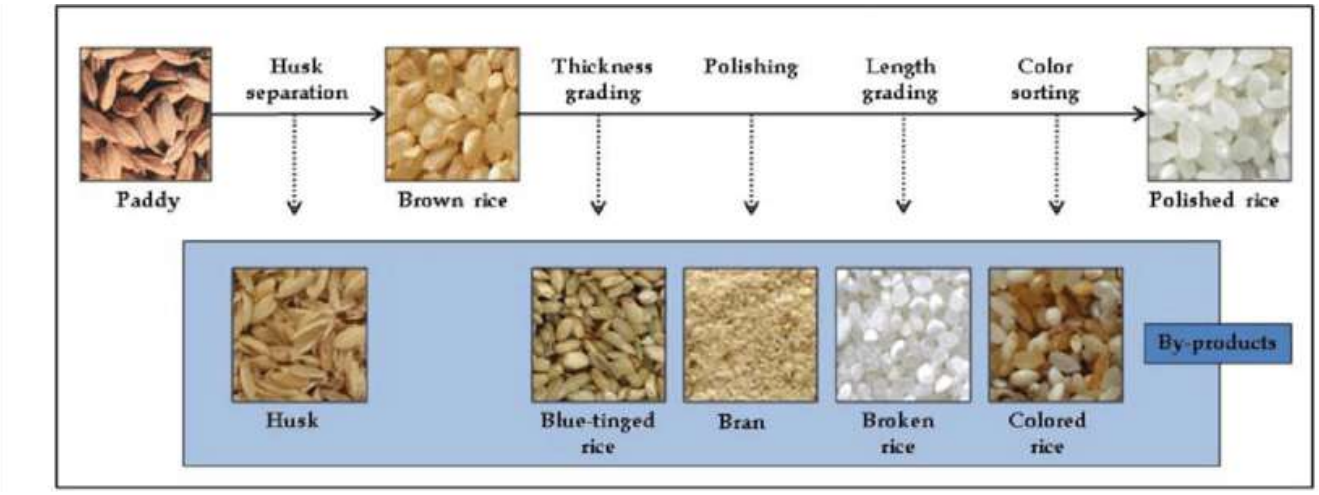
- **Moisture Content:** One of the critical parameters checked is the moisture content of the paddy. Proper moisture levels ensure the longevity and quality of the rice. Moisture meters are often used to measure the moisture content accurately.
- **Purity:** The paddy is inspected for foreign materials such as stones, straw, weeds, etc.
- **Physical Appearance:** The overall physical appearance of the paddy, including color, size, and uniformity, is assessed. Discolored or damaged grains will affect the quality and market value of the rice.
- **Varietal Purity:** In some cases, especially for specific rice varieties, the purity and authenticity of the paddy variety are checked to ensure that it meets the desired quality standards.

Processing of Paddy

- **Pre-cleaning:** The initial cleaning process involves removing large impurities such as stones, sticks, and straw using pre-cleaning machines.
- **Dehusking (Hulling):** The paddy is then placed into a huller machine, which removes the outer husk from the rice grain, producing brown rice.
- **Separation of Brown Rice and Husk:** The brown rice obtained from the huller is separated from the husk using a separator machine.
- **Polishing:** The brown rice undergoes a polishing process to remove the outer bran layer and germ, resulting in polished white rice.
- **Head rice separation:** The polished rice is separated into head rice, larger broken, and small broken rice.
- **Grading and Sorting:** The polished rice is primarily separated based on color and appearance. This step improves the quality of rice by removing defective, discolored, and

foreign materials. The end product has a uniform consistency and safety and increases the market value of rice.

- **Packaging:** The sorted and graded rice is packaged into bags or containers for distribution and sale. Proper packaging ensures the quality and shelf-life of the rice.



Types of Rice Produced

Raw Rice

Raw rice, also known as white rice, is the most common and widely consumed rice type worldwide. It undergoes a milling process that removes the husk, bran, and germ layers, leaving behind the starchy endosperm. The resulting grain is polished to achieve a clean, white appearance. Raw rice is preferred for its fluffy texture, mild flavor, and versatility in various culinary applications.

Steam Rice

Steam rice goes through a unique steaming process, conducted in tanks without prior paddy soaking. This sets this variety apart. After steaming, the rice is milled to remove the husk and chaff and then polished to perfection, leaving only the endosperm.

Parboiled Rice

Parboiled rice is a distinct variety with its own unique processing method. In parboiling, the rice paddy undergoes soaking, steaming, and drying before milling. Parboiled rice is popular because it maintains shape and firmness during cooking. The partial gelatinization of the starch during parboiling also imparts a firmer texture, making it less prone to overcooking.

By-products of Paddy Processing

Rice Bran

One of the primary by-products of paddy processing is rice bran, the outer layer removed during milling. Despite being often discarded, rice bran is a nutritional powerhouse. Rich in dietary fiber, essential fatty acids, and antioxidants, rice bran has gained recognition for its

potential health benefits. It is a valuable ingredient in producing edible oil and animal feed and even as a supplement due to its nutritional density.

Rice Husk

As the outer protective layer of the paddy grain, rice husk is separated during milling. With its high silicon content, rice husk finds application in various industries, including the production of bio-energy, animal bedding, and even insulation materials. Transforming rice husk into bio-energy not only reduces waste but also contributes to sustainable energy solutions.

Broken Rice

During the milling process, some rice grains may break or fracture, resulting in what is known as broken rice. It is used in alcohol production, where it plays a crucial role in the fermentation process. Additionally, broken rice finds application as animal feed, contributing to the agricultural sector.

Rice Processing

Introduction

Rice (*Oryza sativa*, Linn.) is one of the oldest and most important food crops of the world. It is staple food for more than half of the World's population. Rice belongs to the *Gramineae* or grass family and the tribe *Oryzeae*. Rice is a semi-aquatic plant which can thrive under flooded soil condition. Rice plant possesses the roots of a dry land crop, which are able to pass moisture from roots to stem and oxygen from leaf through stem to roots. The total area of rice cultivation varied between 350 – 360 million acres globally during the last few years. About 92% of the World's rice crop is produced in the Asian continent (FAOSTAT).

2.2 Rice Milling

Rice milling is carried out either at small scale or large scale. The objective of the rice milling is to remove the husk and bran with minimum possible breakage of endosperm. Paddy is generally harvested at 18 – 25% moisture and then dried to 12 – 13% moisture either on farm or at the mill before processing.

2.3 Milling Procedure

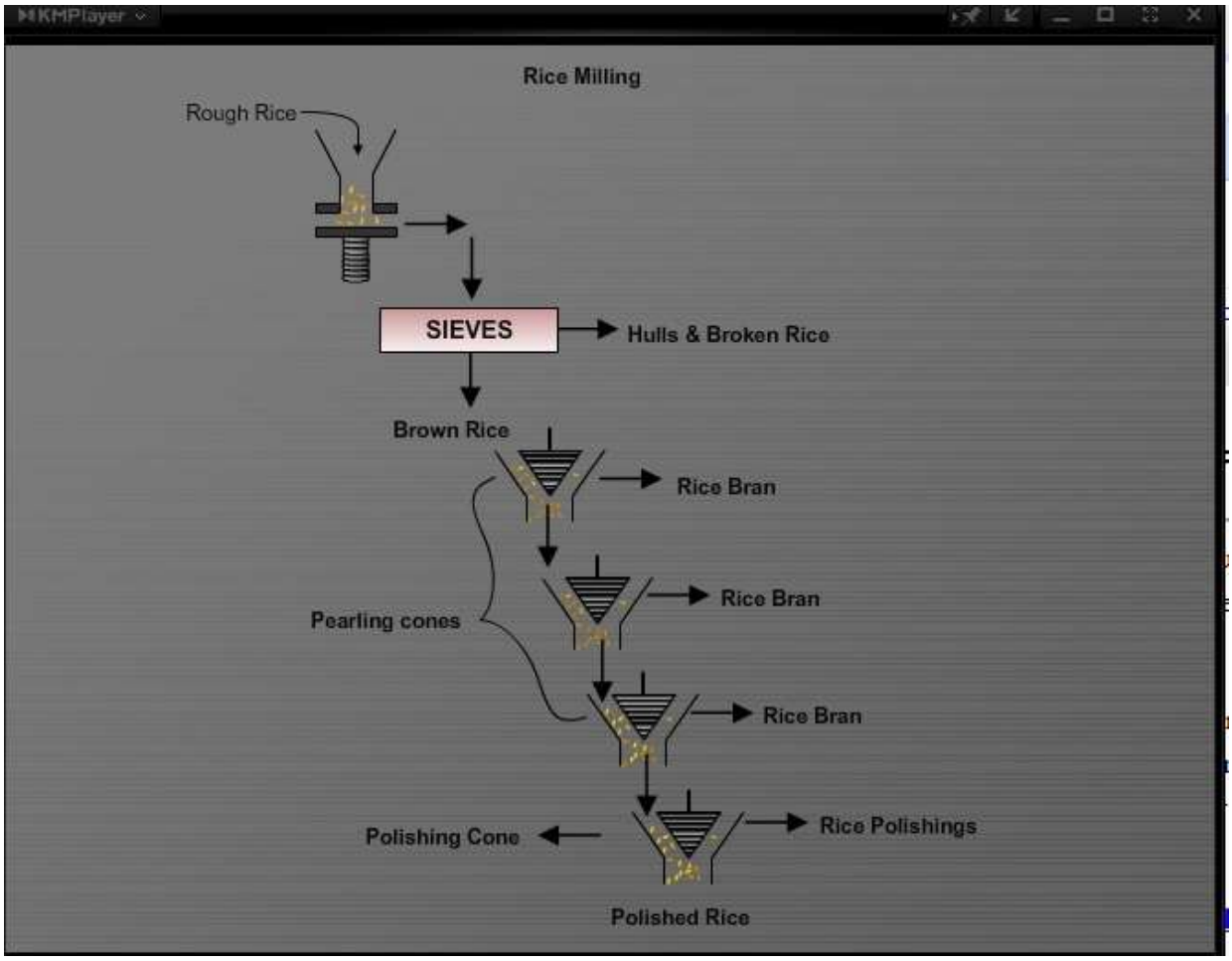
Combine-harvested rice generally has a moisture content of about 20% (wet basis) and the grain must be dried immediately to about 12% for storage. Rice is consumed mostly in the form of whole kernels, and accordingly the processing of paddy is designed to give a high yield of unbroken kenel.

2.3.1 Small scale milling

In case of small scale milling of rice, paddy is placed in a mortar and pounded with pestles either by hands or with the feet. After some time of pounding, the rice is sifted to separate the husk. The pounding process is repeated several times. Rice obtained by this process is called brown rice/rough rice and contain more amount of vitamins as a proportion of the pericarp, testa and aleurone layers remain on the rice grain.

2.3.2 Large scale milling

Schematic representation of the rice milling process is depicted in



2.3.2.1 Cleaning

Cleaning of paddy comprises removal of sticks, stones, dust and other foreign materials. This is accomplished by use of various separation methods. The paddy is first passed over a screen to remove larger particles, straws and string. After that it is passed through second screen, which is having smaller perforations than first screen, to remove weed seeds and sand. The paddy then flows in the form of a thin layer into a channel where an air current removes dead grains and other lighter impurities. At the last, paddy are passed through magnetic separator to remove metal particles.

2.3.2.2 Hulling/Shelling

Cleaned paddy is then passed through machine (disc huller/ sheller) comprising emery/ rubber rolls running in opposite directions; aspirated to remove husk and then sieved to separate from the unhusked and broken rice. The rice with the hull removed is commonly known as ﷺbrown riceﷺ/ﷺrough riceﷺ.

2.3.2.3 Scouring/Pearling/Whitening

Gradual removal of germ and bran from the rough rice is known as scouring/pearling/whitening process. The hulled rice is passed through a series of ﷺpearling conesﷺ. In pearling cones rice passes through the narrow annular space left between an inverted cone coated with abrasive revolving in a conical casing made of steel wire cloth. As it passes down, the bran is pushed through the interstices of the wire cloth. By-product of scouring process is known as ﷺrice-branﷺ which is used as animal feed. It is also used to extract rice bran oil.

2.3.2.4 Polishing

The rice grain consisting inner layers of bran is passed through polishing machine often referred to as ﷺbrushﷺ. In this machine last bran fraction is removed. The grain is now called ﷺpolished riceﷺ.

2.4 Parboiling of Rice

The technique for parboiling of rice was developed in India to prevent losses occurring due to breakage during hand pounding, especially the long grained varieties. In this technique paddy is soaked in excess water and later on cooked in its husk, the objective being pregelatinizing the starch. Any hairline cracks are sealed due to homogeneous mass of gelatinized starch and thus prevent breakage during milling. The paddy is then drained and dried.

Parboiling can be accomplished in variety of ways. The general scheme is to hydrate (steeping) paddy to 32 ﷺ 38% moisture and partially gelatinize the starch by steam heating at 15 lb. pressure for 10 ﷺ 20 min. Parboiling causes certain physico-chemical changes such as improved milling yields (66 ﷺ 70%), increased resistance to insects and firmer cooked rice texture accompanied by a darker and more yellow endosperm. Parboiling has further advantages like: during soaking and cooking the water soluble vitamins (niacin, riboflavin, and thiamine) which are present in germ and pericarp gets migrated into endosperm and thus improves the nutritional value of parboiled rice. Even proteins present on the grain surface are denatured, become insoluble, and therefore are not removed during washing and cooking.

2.4.1 CFTRI parboiling process (Central Food Technology Research Institute, Mysore)

This was developed to avoid bad smell. The paddy is soaked in hot water (65-70ﷺC). Germ action does not occur in hot water, thus the smell is avoided. Soaking time is reduced to 3-4 hrs.

The CFTRI also developed the pressure parboiling method. Soaking time is only 30-60 minutes and steam is passed through the grain to raise the pressure slowly from an initial 0.28-0.70

kg/cm^2 to 1.41-2.11 kg/cm^2 and this is maintained for 20-30 min. In this method, the processing time is reduced.

2.4.2 PPRC parboiling process (Paddy Processing Research Centre, Thanjavur)

It is also known as chromate soaking process. Chromate at the rate of 50g/100 kg paddy is added to the soaking water which stops germ action and eliminates bad smell.

A high temperature short time process was also developed at the PPRC. Steeped paddy is parboiled and dried concurrently by applying high temperature for a short time. Steeped paddy is fed into sand roaster. The paddy gets completely and uniformly parboiled and its subsequent cooking time is less.

2.4.3 Advantages of parboiling of rice

- Dehusking of parboiled rice is easy and the grain becomes tougher resulting in reduced losses during milling
- Higher yield of head rice from milling because kernel is more resistant to breakage.
- Milled parboiled rice has greater resistance to insects and fungus infection.
- The nutritive value of rice increases after parboiling because the water dissolves the vitamins and minerals present in the hulls and bran coat and carries them into the endosperm.
- The water soluble B vitamins, thiamine, riboflavin and niacin are higher in milled parboiled rice than in milled raw rice.
- Parboiled rice does not turn into a glutinous mass when cooked.

2.4.4 Disadvantages of parboiling of rice

- It has a bad smell due to prolonged soaking.
- It has a dark colour due to heat treatment.
- It requires prolonged cooking time and more fuel.
- Since the oil content is more, the polisher may got choked.
- The heat treatment may destroy antioxidants. Hence, rancidity may develop.
- Due to the high moisture content, mycotoxins may be formed.
- Drying cost is added to the total processing cost, extra capital investment.

2.5 Rice Quality and Grading Standards

Characteristics of rice known and referred to as grain quality largely determine market price and consumer acceptance. The grain quality has many connotations and is perceived differnently depending upon the end use, field of interest, specialization, ethnic

background, etc. quality in rice may be categorized into grain quality indicators and cooking/eating quality indicators.

2.5.1 Grain quality indicators

2.5.1.1 Grain dimension – size and shape

There exist enormous variation in the size and shape of the grins as they are conditioned by large number of genes. Grain dimension is expressed as length, breadth and thickness, whereas shape is expressed as the ratio between the length and breadth. These parameters are the major bases for the characterization of rice varieties. Short grain varieties vary in their length from 3 - 6 mm (length-to-breadth ratio, 2.5-3.0) whereas long grain varieties have a length of 6mm and above (length-to-breadth ratio, more than 3.0). There are three major types of rice – long, medium and short grained, whch are classified by the grain shape (length-to-breadth ratio) and tend to have different properties and hence different uses.

2.5.1.2 Grain colour and translucency

White and translucent rice is preferred by people in most parts of the world. The colour of the duhusked, unpolished rice is usually pale white, creamy white, brown or red. On polishing, the kernel becomes white, translucent or opaque according to the nature of the pericarp and endosperm colour of the brown rice.

2.5.2 Cooking/eating quality indicators

Cooking and processing characteristics of the rice are the factors of primary importance in rice eating areas of the world. Milling, cooking and processing qualities are the fundamental components of quality that determine and establish economic value of rice. Upon cooking, long grain rice is dry and fluffy with individual grains, whereas medium and short grain types are moist and chewy with grains that tend to stick or clump together. Major cooking quality parameters are discussed hereunder.

2.5.2.1 Amylose content

Amylose content is considered as the single most important characteristics for predicting rice cooking and processing behavior. In rice it varies roughly from 15-37%. A high amylose content is usually associated with non-sticky cooking characteristics and vice-versa. Glutinous or waxy rice, which has no or very little amylose content, becomes very sticky on cooking.

2.5.2.2 Gelatinization temperature

The gelatinization temperature of starch is the range of temperature within which the starch starts to swell irreversibly in hot water with a simultaneous loss of crystalinity, and usually varies from 56– to 79–C. It is correlated with the extent of disintegration of milled rice in a dilute alkali solution (1.7-2.0% KOH) measured in terms of alkali spread value. Gelatinization temperature is also positively correlated with the cooking time but not with the texture of cooked grains.

2.5.2.3 Gel consistency

The gel consistency test is the index of cooked rice hardness among high amylose rice. Rice is classified on the basis of gel length as soft, medium and hard. Soft to medium gel consistency is preferred to hard gel consistency. Among high amylose rice, intermediate gelatinization temperature and soft gel consistency are preferred by consumers over low gelatinization temperature and hard gel consistency.

2.5.3 Milling quality

Milling quality means the degree to which the endosperm remains intact at the end of milling. Milling quality, indicated by total milling yield or head rice (milled rice kernels that are three quarters or more of the endosperm length) yield, is expressed as a percentage of rough rice. Breakage during milling process is not desirable.

2.5.4 Nutritional quality

Brown rice contains more nutrients (minerals and vitamins) than milled rice. However, status of nutrients is dependent on genetic variability of rice throughout the world.

2.5.5 Specific quality designations regarding cleanliness, soundness and purity

Special grades are provided for the specific qualities or conditions of rice that affect marketability. These special grades:

1 Rough rice: Parboiled rough rice, Smutty rough rice, Weevily rough rice
2 Brown rice: Parboiled brown rice and Smutty brown rice for processing
3 Milled rice: Parboiled milled rice, Undermilled milled rice

In USA rice grade designation follows this order: (1) the letter US (2) no. of grade (3) class (4) applicable special grade (5) milling yield

e.g. U.S. No. 3, long grain rough rice, parboiled, milling yield 50 **-** 70%.