UNIT 2 GRADES AND QUALITY OF PADDY AND RICE

Structure

2.0 Objectives

2.1 Introduction

2.2 Physical Quality
   2.2.1 Factors Affecting the Physical Quality of the Paddy and Rice
   2.2.2 BIS Standards of Quality of Paddy and Rice
   2.2.3 Quality Specifications of Paddy

2.3 Milling Quality
   2.3.1 Husk Content
   2.3.2 Degree of Polish
   2.3.3 Total Yield or Total Rice Outturn
   2.3.4 Head Yield or Whole Rice Outturn
   2.3.5 Broken Content

2.4 Cooking Quality
   2.4.1 Cooking Time
   2.4.2 Water Absorption Ratio
   2.4.3 Swelling Ratio (volumetric)
   2.4.4 Elongation Ratio
   2.4.5 Gelatinization Temperature
   2.4.6 Amylose Content
   2.4.7 Gel Consistency
   2.4.8 Texture

2.5 Nutritive Quality
   2.5.1 Total Protein
   2.5.2 Vitamin Content
   2.5.3 Minerals
   2.5.4 Fats
   2.5.5 Fibre

2.6 Let Us Sum Up

2.7 Key Words

2.8 Some Useful References

2.9 Answers to Check Your Progress

2.0 OBJECTIVES

After reading this unit, you should be able to:

- specify different factors that affect the quality of paddy/rice and explain their importance; and
- understand different quality grades of paddy and rice.
2.1 INTRODUCTION

Quality of paddy and rice specifies the standards for cleanliness purity, shape and size, milling yields, cooking behaviour and nutritive value of rice required for human consumption. Quality consciousness amongst producers, processors, store keepers and consumers is essential for eliminating losses and making good quality food available for the people whose main food source is rice and its products. This chapter describes the factors affecting physical, milling, cooking, and nutritive quality of paddy and rice, and their importance in measuring the quality. The detailed step by step procedure for the measurement of each quality factor is given separately in practical chapter.

2.2 PHYSICAL QUALITY

2.2.1 Factors Affecting the Physical Quality of the Paddy and Rice

1. Variety, amylose
2. Size, shape and weight and uniformity of grains
3. Colour
4. Odour (Flavour and aroma)
5. Hardness and Brittleness
6. Test weight, kilogram per hectar liter weight
7. Moisture content
8. Dockage

2.2.1.1 Variety

In many countries like India, rice is consumed since very early ages and there are large numbers of varieties grown in different regions. On the other hand developed countries like USA, Japan, Spain etc. have reduced the number of varieties to a very small number by their breeding programs. Less number of varieties reduce the problems associated with milling and storage.

Rice varieties are classified into three major groups /grades based on their amylose content

1. High amylose, non-waxy Indica varieties
2. Low amylose, waxy Japonica varieties
3. Aromatic rice varieties.

2.2.1.2 Size, shape and weight and uniformity of grains

These factors form the main basis for grading of rice into various quality groups such as long fine, medium, short bold, or super fine, medium and coarse rice.

Size: Size of rice is measured by the length which is the greatest dimension of the grain.

Shape: Shape of rice is characterized by its slenderness or length to width ratio.

Weight: Weight is determined by taking the mean of the weight of 1000 kernels representative sample

Length of the kernels is measured by a simple laboratory scale or a vernier caliper, where as mass of 1000 grains is measured by an accurate physical or electronic balance.
Size and shape are used as basis for grading rice and paddy into quality grades as shown in table 2.1 below.

<table>
<thead>
<tr>
<th>Grain type</th>
<th>Quality grade</th>
<th>Length (mm)</th>
<th>L/B ratio</th>
<th>Weight (mg)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Long grain</td>
<td>Fine rice</td>
<td>6.61-7.5</td>
<td>Over 3</td>
<td>15-20</td>
</tr>
<tr>
<td>Medium grain</td>
<td>Medium rice</td>
<td>5.51-6.6</td>
<td>2.1 to 3</td>
<td>17-20</td>
</tr>
<tr>
<td>Short grain</td>
<td>Coarse rice</td>
<td>Up to 5.5</td>
<td>Up to 2.1</td>
<td>20-24</td>
</tr>
</tbody>
</table>

These grades are further classified into long slender, medium slender, short bold etc.

Weight of rice grain varies considerably with moisture content. Therefore in its place true density of rice serves as a better standard for quality of grain which can be easily determined by air compression pychnometer.

Uniformity of grains is measured by calculating coefficient of variation for each dimension of representative sample.

2.2.1.3 Colour

Colour of milled rice shows its general appearance and is visually measured by comparison of known standard sample to the unknown one to grade its colour. Colour can also be measured by colour meter which measures reflectance of a rice sample under different colours to determine yellowness index. Yellowness index is a number which indicates degree of yellowness in white cream colour sample. Higher value indicates yellow-brown colour and lower value is given to white colour samples.


\[
YI = \frac{A - B}{G} \quad (1)
\]

Where YI is yellowness index

A = reflectance of rice sample in amber colour
B = reflectance of rice sample in blue colour
G = reflectance of rice sample in green colour

2.2.1.4 Odour (Flavour and Aroma)

Flavour and aroma is measured by feeding cooked rice to different persons who grade the flavour and aroma of rice.

2.2.1.5 Hardness and Brittleness

Hard mature grains break less during milling. Hardness of grains is measured by an instrument – Kiya hardness tester. In the instrument grain is pressed by a plunger until it cracks. The force required to crack grain is shown on a dial of the tester. Grains requiring more force (greater than 2 kg) to break are hard grains and do not break in milling. These grains yield more head yield and less brokens.

2.2.1.6 Test Weight, Kilogram per Hector Liter Weight

Test weight is the weight of a known volume of grain sample and is measured in terms of mass per unit volume. It is very useful in measuring amount of impurities, immature grains and other impurities. Test weight can be easily measured by filling grains in Dalda can to its full and leveling the grains by a straight edge, and then determining the mass of the grains contained in the can by a simple balance. Average test weight of paddy is 58 kg per hector liter. Lower test weight of sample indicates poor quality and presence of immature grains and impurities in the sample.
2.2.1.7 Moisture Content

Moisture content is one of the most important quality factors. It is required to be measured for determining price of grains and for safe storage. Grains can be safely stored at different moisture content for the periods indicated in the table below:

<table>
<thead>
<tr>
<th>Moisture content</th>
<th>20</th>
<th>18</th>
<th>14</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>Storage period</td>
<td>24 hours</td>
<td>2-4 days</td>
<td>3-6 months</td>
<td>1 year</td>
</tr>
</tbody>
</table>

Determination of moisture content is important for determining cut of price during procurement due to high moisture and to determine if drying of grain is necessary before storage or transportation.

2.2.1.8 Impurities and Dockage

Presence of impurities and foreign matter in paddy affect its price in market. Impurities also lower milling yield and some impurities may damage processing machines.

Type of impurities commonly affecting the quality of paddy and rice are given below:

- **Foreign matter** includes organic and inorganic matter. Organic matter includes chaff, straw, weed seeds and other inedible grains. In the case of rice, paddy is also considered as foreign matter. Inorganic matter includes sand, gravel, dirt, pebbles, stones lump of earth, clay and mud.

- **Other food grains**: Any food grain other than the grain concerned.

- **Varietal admixture**: The presence of inferior variety of same grain other than the variety under consideration constitutes varietal admixture.

- **Brokens**: Pieces of kernels that are less than three fourths of the size of the full kernel.

- **Damaged**: Kernels or pieces of kernels that are sprouted or internally damaged as a result of heat, moisture, microbes or weather.

- **Slightly damaged or touched**: Kernels or pieces of kernels that are damaged or discoloured superficially so as not to affect the internal constitution or characteristic of the grain.

- **Discoloured**: Kernels that have changed the colour in processing, handling or storage.

- **Insect damaged**: Kernels that are partially or wholly bored by insects.

- **Chalky**: Kernels or pieces of kernels of which at least half the portion is opaque, milky white in colour and brittle in nature.

- **Red grains**: Kernels or pieces of kernels having more than one fourth of the surface covered with cuticle.

- **Fragments**: Pieces of kernels that are one eighth of the size of full kernels.

2.2.2 BIS Standards of Quality of Paddy and Rice

The Bureau of Indian Standards (BIS), the National Standards Body of India, resolves to be the leader in all matters concerning Standardization, Certification and Quality. The product certification scheme is basically voluntary and aims at providing quality, safety and dependability to the ultimate customer. The certification allows the licensees to use the popular ISI Mark, which has become synonymous with Quality products for the Indian and neighbouring markets over the past more than 40 years. Presence of certification mark known as Standard Mark on a product is an assurance of conformity to the specifications. The conformity is ensured by regular surveillance of the licensee’s per-
formance by surprise inspections and testing of samples, drawn both from the factory and the market

2.2.3 Quality Specifications of Paddy

2.2.3.1 Definitions

*Fair average quality (FAQ)*: refers to the quality of grain in sound merchantable condition, sweet dry clean, wholesome of good food value, uniform in colour and size of grain and free from moulds, weevils, smell, descolouration, admixture of substances or colouring agents and all impurities except to the extent specified by the standards for quality of the grain.

*Superior average quality (SAQ)*: refers to the quality grains confirming to maximum quality limits of impurities admixture and refractions specified in the standards for quality of grain. If the maximum limit for any one of the impurities / admixture / refraction is exceed the lot is down graded to Fair Average Quality

*Tolerance limit (TL)*: refers to the percentage of impurities admixture or refraction below which the grain lot can be accepted without any cut in price. The value of tolerance limit for each impurity refraction and admixture is fixed by the Government

*Rejection Limit (RL)*: refers to the percentage of impurity admixtures or refraction above which grains cannot be accepted or accepted with severe cuts in price for purchase. Cut in purchase price of grain is also made when grain have impurities between tolerance and rejection limit. Rejection limit and the rate of cut at various levels i.e. between TL and RL and beyond RL are fixed by the Government for various grains and refractions in grain.

2.2.3.2 Classification of Rice

Commonly slender rice is considered better in quality than thick fat rice. Based on this rice was classified into superfine, fine, medium, and coarse group depending upon the physical dimensions and shape of the rice grain. This classification was avoided for common market transactions and was more flexible. Five sub-groups depending upon their size and shape to provide uniform standard of classification are given below.

<table>
<thead>
<tr>
<th>Long slender</th>
<th>Length 6 mm and more</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Length / Breadth ratio 3 and greater than 3</td>
</tr>
<tr>
<td>Long Bold</td>
<td>Length 6 mm and more</td>
</tr>
<tr>
<td></td>
<td>Length / Breadth ratio less than 3</td>
</tr>
<tr>
<td>Medium slender</td>
<td>Length less than 6 mm</td>
</tr>
<tr>
<td></td>
<td>Length / Breadth ratio 2.5 to 3</td>
</tr>
<tr>
<td></td>
<td>or Length less than 4.5 mm</td>
</tr>
<tr>
<td>Short slender</td>
<td>length less than 6 mm</td>
</tr>
<tr>
<td></td>
<td>Length / Breadth ratio 2 to 2.5</td>
</tr>
<tr>
<td>Short bold</td>
<td>length less than 6 mm</td>
</tr>
<tr>
<td></td>
<td>Length / Breadth ratio lower than 2.5</td>
</tr>
</tbody>
</table>

2.2.3.3 Grades of paddy for purchase

As explained above paddy / rice is grouped as slender or bold groups. Each group is further divided into three grades viz., grade I, II, and III as described below.
Grade I: If the paddy contains not more than 1% inorganic foreign matter, 1% organic matter, 15% admixture of lower grades and 3% damaged grain, full price will be paid.

Grade II: If the paddy contains any of the above constituents more than that prescribed in grade I but not more than 1% inorganic foreign matter, 2% organic matter, 20% admixture of lower grades and 4% damaged grain, it will be considered as grade II. A lower price of 1% in case of slender group and 0.5% in case of bold group is paid than the prices of Grade I paddy.

Grade III: If the paddy contains any of the above constituents more than that prescribed for grade II but not more than 2% inorganic foreign matter, 3% organic matter, 25% admixture of lower grades and 6% damaged grain, it will be considered as grade III. A lower price paid for grade III will be lower by 2% for slender group and by 1% for bold group than the prices of Grade I paddy.

If the paddy contains any of the constituents more than that prescribed for grade III, it is rejected. However, the supplier has the option to offer stocks under the bold group if the admixtures of inferior varieties in case of stock of paddy offered under slender group are found to exceed 25%. In case of long bold group of paddy, if the stocks contain more than 25% short bold paddy, the same shall be accepted under short bold group.

2.2.3.4 Specifications for fair average paddy of all varieties

The paddy shall be in sound, merchantable condition, sweet, dry, clean wholesome of food value, uniform in colour and size of grain and free from moulds, weevils, small, colouring agents and all impurities except to the extent indicated below in table 2.3:

<table>
<thead>
<tr>
<th>Constituents of admixture</th>
<th>Tolerance limit percent (TL)</th>
<th>Rejection limit Percent (RL)</th>
<th>Rates at which cuts shall be imposed for admixture or impurities exceeding the tolerance limits specified in column (2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign matter</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>a) Inorganic</td>
<td>1.0</td>
<td>2.0</td>
<td>TL to RL at full value</td>
</tr>
<tr>
<td>b) Organic</td>
<td>2.0</td>
<td>4.0</td>
<td>Beyond RL at 1½ value</td>
</tr>
<tr>
<td>Admixture of lower grades</td>
<td>10.0</td>
<td>25.0</td>
<td>TL to RL at ¼ value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beyond RL at ½ value</td>
</tr>
<tr>
<td>Damaged, weevilled, immature, shrunken, sprouted and discoloured grains</td>
<td>3.0</td>
<td>6.0</td>
<td>TL to RL at full value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beyond RL also at full value</td>
</tr>
<tr>
<td>Moisture</td>
<td>15.0</td>
<td>18.0</td>
<td>TL to RL at full value</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Beyond RL at double value</td>
</tr>
</tbody>
</table>

Check Your Progress 1

Note: a) Use space given below for your answers.

b) Check your answers with those given at the end of the unit.

1. What are the factors affecting the physical quality of paddy?
2. What is yellowness index?

3. How do you classify grains based on size and shape?

4. Explain the importance of moisture content in safe storage?

5. What are the impurities that affect the quality of paddy and rice?

6. Explain the different grades of paddy for purchase?

7. What is tolerance limit?

2.3 MILLING QUALITY

Milling quality of paddy is the measure of its performance during the milling process. The measuring of milling quality of paddy is not only important in the rice processing industry, because it reflects, the varietal character, harvesting condition and effect of pre-processing treatments given to paddy, it is equally important in the fields of research associated with rice breeding and post harvest technology of paddy and rice. The measurement of milling quality of paddy also provides a basis for measuring the effectiveness of new treatment given to paddy during production and processing. Milling quality of paddy is measured in terms of following factors.

1. Husk content
2. Degree of polish
3. Total yield or total rice outturn
4. Head yield or whole rice outturn
5. Broken content
2.3.1 Husk Content
The husk content of paddy which varies from 20 to 26% of the weight of paddy for different varieties, affects the total yield of rice in the same proportions. The percentage husk content is expressed using the equation given below

\[
\text{Husk content } \% = \frac{\text{Wt. of husk}}{\text{Wt. of paddy shelled}} \times 100
\]  

(2)

2.3.2 Degree of Polish
The degree of polish is a measure of the percent bran removed from the brown rice kernel. Degree of polish affects milling recovery and influences consumer acceptance. Apart from the amount of white rice recovered, milling degree influences the color and also the cooking behavior of rice. Un-milled brown rice absorbs water poorly and does not cook as quickly as milled rice. The water absorption rate improves progressively up to about 10% milling degree after which, there is very little effect.

Degree of polish given to the rice is calculated from the ratio of weight of bran to the weight of brown rice originally taken for polishing, i.e.

\[
\text{Degree of polish } \% = \frac{\text{Wt. of bran}}{\text{Wt. of brown rice}} \times 100
\]  

(3)

2.3.3 Total Yield or Total Rice Outturn
Total yield is the amount of finished rice (whole rice and brokens) obtained from a given amount of paddy and it is expressed as percent weight of the paddy. For a given set of processing machines, the total yield of rice is dependent upon the husk content and colour of the cuticle on the rice kernel of a given variety. Varieties having thick darker cuticle require a higher degree of polish to make them acceptable to the consumers and hence give relatively lower total rice outturn. Therefore total yield is an expression of the potential of a paddy sample to produce rice.

Total yield of rice as defined earlier is calculated as follows:

\[
\text{Total yield } = \frac{\text{Wt. of milled rice}}{\text{Wt. of paddy sample}} \times 100
\]  

(4)

2.3.4 Head Yield or Whole Rice Outturn
Head yield or whole rice outturn is the amount of whole rice obtained by processing a given amount of paddy and it is also expressed as the percent weight of the paddy sample. Head rice normally includes broken kernels that are 75-80% 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.

Head yield of rice is affected by harvesting conditions and pre-processing treatments given to rice along with the varietal differences. Scientists while developing improved varieties of rice have observed that certain varieties are soft in nature and consequently they break more during processing, thus giving poor head rice outturn. Similarly, it was observed that head yield of a given variety is dependent upon the moisture content of paddy grain and the weather during the harvest-season. Head yield of a variety also varies with the methods adopted for drying the paddy grain, and any other pre-processing treatment such as soaking or parboiling.

Paddy harvested at higher moisture content and dried by a mechanical dryer gives better head yield after milling when compared to paddy dried in the field by sun energy on the plant stalk itself. Non uniform drying of paddy in the sun, develops temperature and moisture stresses in an individual paddy kernel responsible for sun checks or cracks in the kernel and thus results in poor head yield of the paddy.
Head Yield = \( \frac{\text{Wt. of head rice}}{\text{Wt. of paddy sample}} \times 100 \) (5)

2.3.5 Broken Content
Broken content is the amount of broken rice obtained by processing a given amount of paddy and it is also expressed as the percent weight of the paddy

\[ \text{Broken content} = \frac{\text{Wt. of broken rice}}{\text{Wt. of paddy sample}} \times 100 \] (6)

Check Your Progress 2

Note: a) Use space given below for your answers.
   b) Check your answers with those given at the end of the unit.

1. What are the factors affecting the milling quality of paddy?

2. Do total yield change if husk content increases?

3. How do you measure degree of polish?

4. What are the factors that affect the head yield of paddy?

5. In an experiment 250 g of paddy was dehusked in a rubber roll sheller. 68 g of husk and 30 g of brokens were obtained. Calculate husk content?

6. In the above experiment after dehusking only head rice was polished for 1.5 minutes. 20 g of bran and 40 g of brokens came out of the polisher. Calculate the total yield, head yield and degree of polish?
2.4 COOKING QUALITY

Cooking quality is an important index of quality to determine the cooking behaviour of rice. Quality of cooked rice can be determined by using the following characteristics:

1. Cooking time
2. Water uptake or water absorption ratio
3. Swelling ratio (volumetric)
4. Elongation ratio
5. Gelatinization temperature (Alkali degradation test)
6. Amylose content
7. Gel consistency
8. Texture

2.4.1 Cooking Time

The time required for the rice to be cooked optimally i.e., it had no hard centre when pressed between the fingers, is known as optimal cooking time.

2.4.2 Water Absorption Ratio

The amount of water absorbed by a known quantity of rice when cooked optimally in water in a boiling bath is expressed as “water uptake” or water absorption ratio (grams of water absorbed per gram of rice).

2.4.3 Swelling Ratio (volumetric)

The change in the volume of rice by water absorption in cooking is determined by swelling ratio (volumetric) or volume expansion ratio. It is the ratio of volume of rice after cooking to the volume of rice before cooking.

2.4.4 Elongation Ratio

It is the ratio of the length of the rice after cooking to the length of the rice before cooking.

2.4.5 Gelatinization Temperature

The time required for cooking milled rice is determined by gelatinization temperature or GT. Environmental conditions, such as temperature during ripening, influence GT. A high ambient temperature during development results in starch with a higher GT. 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 varies from 58 to 79°C.

2.4.6 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 groups", as follows:

- waxy (1-2% amylose),
- very low amylose content (2-9% amylose),
- low amylose content (9-20% amylose),
- intermediate amylose content (20-25% amylose) and
- high amylose content (25-33% amylose).

Amylose content of milled rice is determined by using the colorimetric iodine assay index method.

### 2.4.7 Gel Consistency

Gel consistency measures the tendency of the cooked rice to harden after cooling. Within the same amylose group, varieties with a softer gel consistency are preferred, and the cooked rice has a higher degree of tenderness. Harder gel consistency is associated with harder cooked rice and this feature is particularly evident in high-amylose rice. Hard cooked rice also tends to be less sticky. Gel consistency is determined by heating a small quantity of rice in a dilute alkali. The gel consistency is classified as hard (24-40 mm), medium (41-60 mm) and soft (61-100 mm).

### 2.4.8 Texture

Texture describes what we might experience in our mouths when eating rice: initial mouthfeel, hardness, stickiness, cohesiveness, springiness, resilience, gumminess and chewiness. These characteristics are generally measured by a group of people who are very experienced in determining and describing the texture of rice. These groups are called sensory panels. Rice research and development programs in India and other countries, are attempting to identify machines that can sense the different textures and closely match them with scores reported by sensory panels.

The texture of cooked rice is an important quality character. The single grain puncture method is used to measure the texture of single rice grains. This allows us to find out how much texture will vary in any sample of rice.

### Check Your Progress 3

**Note:**

a) Use space given below for your answers.

b) Check your answers with those given at the end of the unit.

1. **What are the factors affecting the cooking quality of paddy?**

2. **What is the importance of gelatinization temperature and how do you measure it?**
3. How do you classify grain based on gel consistency?

4. Classify grains based on amylose content.

5. What is swelling ratio?

2.5 NUTRITIVE QUALITY

Rice is a high-carbohydrate food with 85 percent of the energy from carbohydrate, 7 percent from fat, and 8 percent from protein. However, rice also has a considerable amount of protein, with an excellent spectrum of amino acids. The protein quality of rice (66%) is higher than that of whole wheat (53%) or corn (49%). Of the small amount of fat in brown rice, much is polyunsaturated. White rice is extremely low in fat content.

Table 2.4: The nutritional composition of one cup of cooked rice

<table>
<thead>
<tr>
<th></th>
<th>Brown Rice</th>
<th>White Rice</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calories</td>
<td>218</td>
<td>266</td>
</tr>
<tr>
<td>Protein (g)</td>
<td>4.5</td>
<td>5.0</td>
</tr>
<tr>
<td>Carbohydrate (g)</td>
<td>45.8</td>
<td>58.6</td>
</tr>
<tr>
<td>Fiber (g)</td>
<td>3.5</td>
<td>0.5</td>
</tr>
<tr>
<td>Fat (g)</td>
<td>1.6</td>
<td>0.4</td>
</tr>
<tr>
<td>Polysaturated fatty acids (g)</td>
<td>0.6</td>
<td>0.1</td>
</tr>
<tr>
<td>Cholesterol (mg)</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Thiamin (mg)*</td>
<td>0.20</td>
<td>0.34**</td>
</tr>
<tr>
<td>Vitamin A</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>

*Daily requirement of thiamin is 1.2 mg for an adult man

**Enriched or parboiled rice.

2.5.1 Total Protein

Rice protein has one of the highest nutritive values among cereal protein because of its lysine content. Next to starch, protein is the second most abundant constituent of brown rice. In brown rice it is distributed as 8% in bran, 6% in germ, 3% in polish, and 83% in milled rice. Protein content is usually measured from Kjeldhal nitrogen multiplied by the factor 5.95. This factor is based on the average nitrogen content of the major rice protein of 16.8%. The major protein is alkali-soluble (glutenin) type, with proportions of water soluble (albumin), salt soluble (globulin) and alcohol soluble (prolamin) proteins.
2.5.2 Vitamin Content

Vitamins are present in higher levels in brown rice than in milled rice and located in the aleurone layers and embryo. In brown rice 65% of the thiamine is in the bran (58% in embryo), 13% in polish, and the rest in milled rice. Riboflavin is distributed as 39% in bran (24% in embryo), 8% in polish and 53% in milled rice. The distribution of niacin is 54% in bran (18% in embryo), 13% in polish, and 33% in milled rice.

Rice contains little or no vitamin A (ascorbic acid), or vitamin D, but vitamin E content of brown rice is considerable. Parboiled milled rice contains a higher amount of B vitamins than does raw milled rice. Standard chemical methods are available to extract and oxidize thiamin to thiochrome, which is measured fluorimetrically. Fluoresces is used to measure the Riboflavin.

2.5.3 Minerals

The mineral composition of rice depends considerably on the availability of soil nutrients during crop growth. Minerals are generally present in higher levels in brown rice than in milled rice. A considerable portion of the rice caryopsis is accounted for phosphorous. Potassium, magnesium and silicon are present also in large amounts in brown and milled rice. By contrast, silica is the major element in hull ash. Iron and calcium, two of the most important elements for human nutritional requirements are usually present less than the optimal amounts in rice.

2.5.4 Fats

The fat content of rice is low, 2.0 to 2.5%. Much portion of the lipids of rice is in the bran and is lost during milling. Milled rice contain only about 0.3 to 1% of fat.

2.5.5 Fibre

The crude fibre largely contains cellulose material. The fibre content in rough rice is 8 to 12% whereas in brown rice it is less than 3% and in milled rice less than 2%.

Proteins, fats, vitamins and minerals are present in greater amounts in the germ and outer layers than in starchy endosperm. So the degree of milling and polishing greatly affects the nutritive value of the rice. The table 2.5 shows the loss of nutrients due to milling and polishing.

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Losses on milling and polishing</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fat</td>
<td>84-86.5</td>
</tr>
<tr>
<td>Ash</td>
<td>24.1-78.5</td>
</tr>
<tr>
<td>Protein</td>
<td>6.0-29.4</td>
</tr>
<tr>
<td>Carbohydrates</td>
<td>5.5-6.5</td>
</tr>
</tbody>
</table>

Courtesy: Bandyopadhyay and Roy (1992)

Rice is usually washed before cooking, often with change of water several times, to remove dust and other impurities. Washing with excess water cause consider loss of water soluble vitamins and nutrients (table 2.6). Using of alkaline or hard water for cooking cause loss of thiamin than the normal washing.
Table 2.6: Losses of nutrients in washing and cooking

<table>
<thead>
<tr>
<th>Nutrient</th>
<th>Loss in washing (%)</th>
<th>Loss in washing and cooking</th>
</tr>
</thead>
<tbody>
<tr>
<td>Vitamin B1 (Thiamine)</td>
<td>55</td>
<td>85 (From raw milled rice)</td>
</tr>
<tr>
<td></td>
<td>9</td>
<td>34 (From parboiled milled rice)</td>
</tr>
<tr>
<td>Riboflavin</td>
<td>25</td>
<td></td>
</tr>
<tr>
<td>Niacin</td>
<td>23</td>
<td></td>
</tr>
<tr>
<td>Proteins</td>
<td></td>
<td>10</td>
</tr>
<tr>
<td>Iron</td>
<td></td>
<td>75</td>
</tr>
<tr>
<td>Calcium and Phosphorous</td>
<td></td>
<td>50</td>
</tr>
<tr>
<td>Calories</td>
<td></td>
<td>15</td>
</tr>
</tbody>
</table>

*Courtesy: Bandyopadhyay and Roy (1992)*

**Check Your Progress 4**

**Note:**

a) Use space given below for your answers.

b) Check your answers with those given at the end of the unit.

1. How do you measure the nutritional quality of paddy?

2. How do you measure the protein content?

3. Give the nutritional composition for one cup (60 gms) of brown rice?

4. What is the fat and fibre content in rice?

5. Will increase in degree of polish increase the nutritional properties of rice? Explain?
6. Which nutrients and minerals lost during repeated washing and cooking of rice?

2.6 LET US SUM UP

Quality of paddy and rice can be divided into physical quality, milling quality, cooking quality and nutritive quality. Factors affecting the physical quality of paddy and rice are size, shape and weight and uniformity of grains, hardness and brittleness, colour, test weight, kilogram per hectare, weight, impurities and foreign matter. Milling quality of rice is expressed through (1) total rice outturn or total yield and (2) head rice outturn or head yield. Quality of cooked rice can be determined by using cooking time, water uptake or water absorption ratio, swelling ratio (volumetric), gelatinization temperature, amylose content, gel consistency and texture. Nutritive quality includes total protein, vitamin content, minerals, fats and fibre in the paddy or rice.

2.7 KEY WORDS

<table>
<thead>
<tr>
<th>Term</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>Organic matter</td>
<td>Includes chaff straw, weed seeds and other inedible grains. In case of rice, paddy is also considered as foreign matter.</td>
</tr>
<tr>
<td>Inorganic matter</td>
<td>Includes sand, gravel, dirt, pebbles, stones lump of earth, clay and mud.</td>
</tr>
<tr>
<td>Other food grains</td>
<td>Any food grain other than the grain concerned.</td>
</tr>
<tr>
<td>Varietal admixture</td>
<td>The presence of inferior variety of same grain other than the variety under consideration constitutes varietal admixture.</td>
</tr>
<tr>
<td>Brokens</td>
<td>Pieces of kernels that are less than three fourths of the size of the full kernel.</td>
</tr>
<tr>
<td>Damaged</td>
<td>Kernels or pieces of kernels that are sprouted or internally damaged as a result of heat moisture, microbes or weather.</td>
</tr>
<tr>
<td>Slightly damaged or touched</td>
<td>Kernels or pieces of kernels that are damaged or discoloured superficially so as not to affect the internal constitution or characteristic of the grain.</td>
</tr>
<tr>
<td>Discoloured</td>
<td>Kernels that have changed the colour in processing, handling or storage.</td>
</tr>
<tr>
<td>Insect damaged</td>
<td>Kernels that are partially or wholly bored by insects.</td>
</tr>
<tr>
<td>Chalky</td>
<td>Kernels or pieces of kernels of which at least half the portion is opaque, milky white in colour and brittle in nature.</td>
</tr>
<tr>
<td>Red grains</td>
<td>Kernels or pieces of kernels having more than one fourth of the surface covered with cuticle.</td>
</tr>
<tr>
<td>Fragments</td>
<td>Pieces of kernels that are one eighth of the size of full kernel.</td>
</tr>
</tbody>
</table>
2.8 SOME USEFUL REFERENCES


2.9 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Variety, Size, shape and weight and uniformity of grains, Colour, Odour (Flavour and aroma), Hardness and Brittleness, Test weight, kilogram per hectar liter weight, Moisture content and Dockage.

2. Yellowness index is the measure of colour. It is determined by the reflectance of a rice sample in the colour meter. Expressed as (A-B)/G where A, B and G represents reflectance of colour light Amber, blue and green respectively.

3. Fine, medium and coarse.

4. Moisture content 20 for 24hrs, 18 for 2-4 days, 14 for 3-6 months, 12 for 1year.

5. Foreign matter, Organic matter, Inorganic matter, Other food grains, Varietal admixture, Brokens, Damaged, Slightly damaged or touched, Discoloured, Insect damaged, Chalky, Red grains and Fragments.

6. Grade I: 1% inorganic foreign matter, 1% organic matter, 15% admixture of lower grades and 3% damaged grain Grade II: constituents more than that prescribed in grade I but not more than 1% inorganic foreign matter, 2% organic matter, 20% admixture of lower grades and 4% damaged grain Grade III: constituents more than that prescribed for grade II but not more than 2% inorganic foreign matter, 3% organic matter, 25% admixture of lower grades and 6% damaged grain.

7. Percentage of impurities admixture or refraction below which the grain lot can be accepted without any cut in price.

Check Your Progress 2

1. Husk content, Degree of polish, Total yield or total rice outturn, Head yield or whole rice outturn, and Broken content.

2. Yes, if the husk content increases the total yield decreases.

3. Weight of bran/weight of brown rice x 100.

4. Varieties, Harvesting conditions i.e., moisture content of paddy grain and the weather during the harvest-season, methods adopted for drying the paddy grain, and any other pre-processing treatment such as soaking or parboiling.

5. \((68/250) \times 100 = 27.2\%\)
General

6. Total milled rice = paddy-husk-bran = 250-68-20 = 162, total yield = \((162/250)\times100 = 64.8\%\), Total head rice = total milled rice - brokens = 162-20-30 = 112, head yield = \((112/250)\times100 = 44.8\%\), brown rice used in polish meter = 250-68-30 = 152, degree of polish = \((20/152)\times100 = 13.15\%\)

Check Your Progress 3

1. Cooking time, Water uptake or water absorption ratio, Swelling ratio (volumetric), Elongation ratio, Gelatinization temperature (Alkali degradation test), Amylose content, Gel consistency, and Texture
2. Gelatinization temperature tells about the time required for cooking milled rice. GT of milled rice is evaluated by determining the Alkali spreading value.
3. hard (24-40 mm), medium (41-60 mm) and soft (61-100 mm)
4. waxy (1-2% amylose), very low amylose content (2-9% amylose), low amylose content (9-20% amylose), intermediate amylose content (20-25% amylose) and high amylose content (25-33% amylose).
5. Ratio of volume of rice after cooking to the volume of rice before cooking.

Check Your Progress 4

1. By measuring total protein, vitamin content, minerals, fats and fibre
2. Protein content is measured from Kjeldhal nitrogen multiplied by the factor 5.95. This factor is based on the average nitrogen content of the major rice protein of 16.8%.
3. Calories 218, Protein 4.5 g, Carbohydrate 45.8 g, Fiber 3.5 g, Fat 1.6 g, Polyunsaturated fatty acids 0.6 g, Cholesterol - nil, Thiamin 0.20 mg, Vitamin A - nil
4. Brown rice - fat = 1.6g, fibre = 3.5; White rice - fat = 0.4g; fibre = 0.5g (60g) one cup
5. Proteins, fats, vitamins and minerals are present in greater amounts in the germ and outer layers than in starchy endosperm, so increase in degree of polish decreases the nutritional quality
6. Water soluble minerals and nutrients