UNIT 12 RICE BROKENS

Structure

12.0 OBJECTIVES

After reading this unit, you should be able to:

- know the meaning of rice brokens;
- learn regarding equipment for grading of brokens, separation and purification of germ;
- get information on value added products produced from brokens;
- explain steps for production of various rice brokens based items;
- know the important considerations in the process technology; and
- learn regarding changes in nutrition values of the product.

12.1 INTRODUCTION

Milling of paddy is the main step in paddy processing. It consists of removing the husk and outer bran layers to produce acceptable white rice. The final white rice contain broken grains(rice kernels less than $3/4^{th}$ of the size of the whole grain) varying between 30 and 50% depending upon the pre-and post harvest operating conditions, paddy variety and the type of milling machinery. Brokens not only reduce rice yield but lead to economic loss as well, due to its very low selling price. Leaving aside a permissible limit of mixing 18 to 25 % of these broken grains in milled rice, it may still be considered an undesirable loss to the nation.

In India, the selling price of broken rice is about $1/3^{rd}$ the price of whole rice and it is largely used as feed, brewing adjunct and as raw material for preparation of breakfast foods, such as idli, dosa etc. However considerable potential and need still remain for development of some value added products using this relatively cheaper by-product of the rice milling industry. Even though modern rice milling systems are very efficient, some rice kernels inevitably yield high percentage of brokens sometime during the milling process. After the paddy is milled, it is necessary to separate broken kernels from the whole grains. Depending upon the level of brokens allowed by the customer's specification, these broken grains may be blended in a precise ratio with whole grain kernels to maximize the profitability of the mill.

12.2 GRADING OF BROKENS

12.2.1 Equipment for the Grading of Brokens

12.2.1.1 High capacity grading sifter

The grading sifter uses a rotary or vibratory motion to expose grains to a surface that is made of perforated metal or woven wire cloth. Grains shorter than a certain size fall through the openings in the cloth, while longer kernels remain on the sifting surface.

12.2.1.2 Indented Cylinder Grader

In this machine, rice is placed inside a cylinder that has indentations punched into its inner surface. As the cylinder rotates, rice kernels are lifted by the indentations. Depending upon the length of the individual grains, they fall from the indentations at different points. The broken grains, which are shorter than the unbroken kernels, remain in the cylinder longer, and are lifted to greater heights. An adjustable collecting trough is positioned so as to select the size and amount of brokens to be removed.

12.2.1.3 Electrical Sorting

Modern rice millers are able to remove almost all foreign objects from paddy during the milling process through magnets and mechanical means. But there may be some nonmagnetic objects that are similar in size and density to whole or broken rice kernels, and these are very difficult to remove using mechanical means.

To remove such foreign objects, it is common to use devices that can differentiate between rice kernels and the foreign objects on the basis of their appearance. These devices are commonly referred to as "Colour Sorters".

12.2.1.4 Optical Sorter

In this machine, rice kernels are made to fall at a specific speed down a path, causing them to pass through the focal point of a camera. The camera gathers light, which is reflected from an adjustable plate known as the "Background." A photoelectric sensor then converts the gathered light into an electrical signal, the magnitude of which is proportional to the intensity of the reflected light. Any grain that appears darker than the background results in a negative voltage. A trigger mechanism, called the "sensitivity control," allows the operator to define how dark an object must be in order to be considered "objectionable." A microprocessor then analyzes the signal, compares it to the magnitude that is considered objectionable, and if appropriate, sends a signal to an electromagnetic valve. The valve is energized, opens, and allows a blast of compressed air to escape. The compressed-air blast deflects the undesirable kernel from the rice stream, removing it from the finished product.

Check Your Progress 1

Note: a) Use the spaces given below for your answers.

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

1. Describe broken rice.

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2. What are the important parameters which affect the level of brokens in milled rice?

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3. What is the permissible limit of brokens in milled rice?

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4. List the equipment for grading of brokens.

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5. What is the main principle of "Colour Sorter"?

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6. Describe the working of Optical Sorter.

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12.3 SEPARATION AND PURIFICATION OF RICE GERM

Rice germ is embryo-the rudimentary form of future plant. It is extremely small and is located on the ventral side of the caryopsis. It has 2 to 3 %weight of brown rice. The embryo has 4.8 to 7.4 % pentosans, 4% cellulose, 3 to 6 % lignin, 11.6% reducing sugar, 2.1% non-reducing sugar and 0.8% phytin phosphorous. Albumin and globulin are concentrated in the germ. The protein efficiency ratio of germ is 2.59 and biological value (BV) 78. The germ contains 4.6% of free amino acids in its protein. Rice germ is high in phosphorous and low in calcium; it contains somewhat more sodium and much less silica. Germ is also rich in vitamins. Purified germ has a bulk density of 0.51 g/cc.

12.3.1 Seperation

To maintain the nutritive value of milled rice, germ-remained (milled) rice- in which germ is remained in more than 80% of the grain- has been produced in many commercial mills in Japan. In other countries germ forms an integral part of bran in the mill-stream. Because of the embedding of germ with scutellum and endosperm during parboiling, most of the germ is retained in the milled parboiled rice.

12.3.1.1 Laboratory-level Separation of Germ

50 gm bran (bran and germ) previously sifted is led on the screen. Air is passed through it upwards. When pressure, as indicated in the manometer, is about 2 cm H_2O column, light impurities are removed. When pressure is about 10 cm H_2O column, rice germ is aspirated, leaving on the screen brokens, stones, and heavy impurities.

12.3.1.2 Pneumatic Rice Germ Separator

The horizontal set up consists of a blower coupled to an AC motor, conveyance pipe, feeding hopper, mixing nozzle, expansion chamber and cyclone separator. The vertical set up consists of a blower coupled to an AC motor, conveyance pipe with feed back arrangement, feeding hopper, mixing nozzle, settling chamber and cyclone separator. It has separation efficiency of 61%.

12.3.1.3 Degermer

A laboratory level batch degermer is in operation at the paddy processing research centre (PPRC) Tiruvarur, India. It consists of a main shaft with 4 metal prongs. When the brown rice is fed into the perforated chamber, the germ is removed due to the friction caused between the grains. The germ recovery is 90 to 95%. During this process, about 2.5 % bran also is removed along with germ.

12.3.2 Purification

The germ coming out the sifter still contains bran, husk, brokens and other impurities. Purification is carried out by sieving through a shaking device comprising the 3 sieves : mesh number 20 (ASTM) (0.8 mm ϕ) for separating residual bran ; mesh 1.5 mm ϕ for separating germ and mesh 2 mm ϕ, for separating rice powder.

After sieving, the air blowing upward further cleans the germ fraction. Air speed in the aspiration system may vary greatly, depending on the physical characteristics of the byproducts.

Check Your Progress 2

Note: a) Use the spaces given below for your answers.

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

1. Describe rice germ with composition.

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2. List the machinery for separation of rice germ.

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3. What is the working principle of degermer? Mention germ recovery.

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4. List the sieves used for purification of rice germ.

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12.4 RICE FLOURS AND SEMOLINA

In the wheat industry, milling always produces flour. In the rice industry, the terminology differs. Milling usually refers to the removal of bran for producing polished rice, and grinding broken or polished rice produces rice flour. The applications of rice flour include traditional Asian foods and baked goods, many of which have now spread around the world. Rice flour can also be used to produce gluten-free rice bread for gluten-sensitive individuals and is typically used in baby foods. Thailand, a major exporter of rice flour, offers a price near the world average. China, the principal rice producer, offers the lowest price for rice flour in the market. The world average price of rice flour showed a steady growth from 1990 to 2000, which indicates a growing market for rice flour.

Based on starch type, there are two primary types of commercial rice flours available in the market. The first is produced from glutinous or sweet rice and is used for making many types of oriental snack foods, as well as a thickening agent in white sauces, gravies, puddings, and prepared frozen foods. It can prevent liquid separation that occurs when some food products are frozen, stored, and subsequently thawed. The other major type of rice flour is prepared from broken grains of non-glutinous raw or parboiled rice. The rice flour made from parboiled rice is essentially pre-cooked rice flour. Rice flour differs from wheat flour in baking properties because rice flour does not contain gluten, and its dough does not retain gases generated during baking. Gluten in wheat flour provides elasticity in the dough to allow retention of CO_2 gas generated during baking. Rice flours can be used in a wide range of applications including ready-to-eat breakfast cereals, crispy rice for candies and snacks, infant cereals, French-fry coatings, extender in powdered cheeses and powdered sugars, waffle and pancake mixes and sauces, soups and gravies. These industrial applications, combined with household needs, are sufficient to sustain a market for rice flour production.

Rice flour is often used as an ingredient in cereals made from other grains. In addition to providing a more tender bite, rice flour in flaked cereals improves flake expansion. Waxy rice flour improves bowl life, because the higher amylo-pectin level produces a more hydrophobic gel. Extruded cereals formulated with other grains often include rice flour to improve crispiness and expansion, as well as reduce breakage. Pre gelatinized rice flour can also be used as a functional aid, holding extra water in the product for more expansion and absorbing water faster in the extrusion process, which decreases dwell time.

Rice flour is often used as an ingredient in cracker and chips for many of the same reasons that it is used in multi-grain breakfast cereals: to control moisture, bite, texture and flow in extruders. Long grain rice flour increases crispness, whereas pre-gelatinized or partially gelatinized rice flour improves water absorption and dough sheeting. Chips made from rice flour absorb less fat during frying than those made from potatoes. In addition, baked or fried chips with 5 to 10 % waxy rice flour experience less breakage.

12.4.1 Properties of Rice Flours

Rice flours made from long, medium and short grain and waxy rice are available for commercial and home usage. There are varietal differences in protein, lipid, starch content and by amylose to amylo-pectin ratio in the starch. Differences in chemical composition between rice varieties contribute to the diversity of chemical and physical properties of various rice products. The characteristics of rice flour can be measured objectively by such properties as their viscosity behavior when heated with water, starch gelatinization temperatures, birefringence end point temperature, and water absorption capacity.

12.4.2 Preparation of Rice Flour

Three methods, namely wet, semi-dry, and dry milling are used to prepare rice flour as illustrated in Figure 12.1. Soaking, milling, drying and regrinding are involved in wet milling. Usually rice is soaked in water for more than 4 hours, drained, and ground by a stone mill with water (3 to 5 times the weight of rice). The key purpose of wet milling is to prepare flour while causing only minimal damage to the starch. Damage can be reduced by the cooling and lubricating effects of water. After milling, excess water is removed by drying, and the flour is then gently reground to prepare the wet-milled flour. This flour is generally used for products such as Japanese cake, rice crackers, Taiwanese cakes, rice noodles, Filipino rice cakes and Indian fermented foods such as *idli*, *dosa* etc. The treatment of waste water becomes an issue in most countries.

In semi dry milling, rice is soaked, drained and ground by using a stamp or pinmill without adding any water. Because no excess water is used, the disposal of waste water is eliminated. In general, the applications of semi dry milled flour are similar to those for wet milled flour.

In dry milling, cleaned rice can be directly ground to different sizes by various mills. Different mills (including rolling, pounding, shock, stone, and lateral steel) can be used to prepare rice flour without generating any waste water, but the starch shows more damage, which influences the applications of the rice flour. The particle size of the rice flour plays a key role in the flour properties. Dry milled rice flours usually have the same protein content as does the parent rice and are used for baked products, baby foods, extrusion cooked products and in high protein flour.

12.4.3 High protein Rice Flour

High protein fractions can be used for the nutritional supplements in baby foods or other products, such as instant milk, gruel, and puddings. These foods provide needed protein in the diets of young children in rice eating countries.

12.4.4 Brown Rice Flour

Health conscious consumers are becoming more interested in brown rice flour because of its nutritional value. This flour is prepared via different milling methods, using rough rice as the starting material. The presence of bran imparts a different flavor and chewy texture to products. Unfortunately, brown rice flour has limited shelf-life stability due to the lipase activity initiated in the bran layers during dehusking. The lipid components are enzymatically hydrolyzed, freeing fatty acids and causing rancidity. The rancidity can be minimized when the enzymes are inactivated.

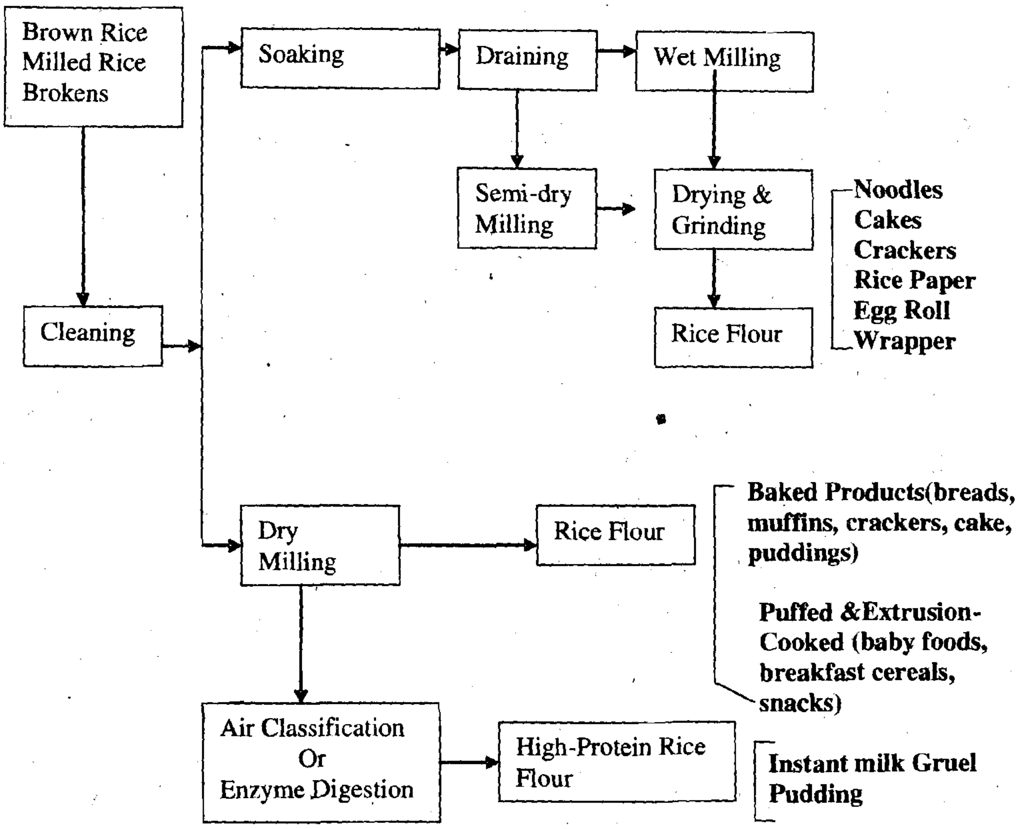

Fig. 12.1: Manufacture of rice flours and their applications

Check Your Progress 3

Note: a) Use the spaces given below for your answers.

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

1. What is the difference in the terminology of "milling" in wheat and rice milling industry?

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2. List the applications of rice flour in food industry.

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3. What are the primary types of commercial rice flours available in the market? Mention their uses.

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4. How do you differentiate rice and wheat flour based on properties?

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5. List the industrial applications of rice flour.

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6. What is the main difference between rice chips and potato chips?

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7. List the properties to measure the characteristics of rice flour.

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8. What are the methods available for making rice flour? Indicate main unit operations in the process.

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9. Describe wet milling and uses of wet mill flour.

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10. What are the advantages and disadvantages of dry milling?

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11. List the uses of dry milled flour.

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12. What are the main features of high protein rice flour?

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13. List the main disadvantages with brown rice flour.

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12.5 EXTRACTION OF STARCH

12.5.1 Commercial Method

Commercial preparation of starch from rice is limited owing to the high cost of brewer's rice relative to other cereals and tubers. Sodium hydroxide is used for purifying milled rice starch because at least 80% of the protein of milled rice is alkali-soluble protein (glutelin). The process consists of steeping broken rice in 0.3-0.5% sodium hydroxide solution, wet milling the steeped grain, removal of cell walls, extraction of the protein with sodium hydroxide solution, washing, and drying. Trash and dirt are removed by preliminary cleaning. Steeping softens the grain and aids in extracting the protein. Steeping temperature varies from room temperature to 50 °C, and the steeping period is usually 24 hr. Wet grinding is preferred to dry grinding, as starch damage is more extensive in dry milling, resulting in greater starch losses through dissolution in alkali. The steeped rice is usually ground or wet milled in pin mills, hammer mills, or stone-mill disintegrators in the presence of sodium hydroxide solution. The starch suspension is then stored for 10-24 hr, after which fiber is removed by passing the suspension through screens, and the starch is collected by centrifugation, washed with water, and dried in a dryer. Usually only one extraction is made, as 97% of the protein of milled rice flour is extracted in 3-6 h with 0.4% sodium hydroxide.

12.5.2 Laboratory Methods

The most common laboratory method of preparing rice starch is by alkali extraction of the protein using 0.2-0.3% sodium hydroxide solution. Milled rice or broken is steeped in 5-6 volumes of 0.2-0.3% sodium hydroxide solution at 25 °C for 24 h to soften the endosperms. The steep liquor is drained off, and the endosperms are pressed and ground lightly in successive small fractions with a mortar and pestle. The slurry is then diluted to the original volume with 0.2-0.3% sodium hydroxide. The mixture is stirred for 10 min and allowed to settle overnight. The cloudy supernatant is drained off, and the sediment is diluted to the original volume with sodium hydroxide solution. The process is repeated until the supernatant becomes clear and gives a negative reaction to the biuret test for protein (10-20 days). Starch is suspended in distilled water, passed through a 100-200 mesh nylon cloth, and repeatedly washed with water until the supernatant no longer shows any pink color with phenolphthalein. The starch is collected by sedimentation or centrifugation, and the white middle portion is collected (thin dark surface and bottom layers are discarded) and air-dried. The whole process takes 20-30 days.

Improvements in the method include homogenization of steeped grain in a Waring blender and passing the resulting mixture through a 200 mesh sieve before the sodium hydroxide treatment. Continuous shaking for 3-6 h is sufficient for alkali extraction of protein and hastens the preparation of starch. Lower alkali concentrations are ineffective for complete extraction of proteins and starch lipids.

Another commonly used method involves treatment with a detergent solution (1-2% dodecyl benzene sulfonate (DOBS) to which 0.2% sodium sulfite is added just before use). Milled rice is steeped in 3-4 volumes of the detergent solution for 24 to 48 h. The supernatant is decanted off, and the residue is crushed in a mortar and pestle to pulverize the milled rice, adding detergent solution as needed. The slurry is passed through a 200-mesh cloth or sieve, and the large particles are ground further in a mortar and pestle. Low-speed grinding of the steeped grain in water may also be employed. The sieved starch is then shaken with 5 volumes of fresh detergent solution for 6h, and the supernatant is removed by centrifugation. This treatment is repeated 3-4 times to remove any trace of protein and fat, and the purified starch is then washed repeatedly with distilled water until the washing becomes negative for sulfate. The starch is then again washed two to three more times with water. The purified starch is collected after discarding the thin layer of darker starch at the surface and bottom and air-dried. Yields are 33-50% of milled rice.

Ultrasonication has been employed for purifying rice starch. About 5 g of milled rice powder suspended in 45 ml of distilled water in a test tube is subjected to 10 kHz for 10-20 min. The homogenate is filtered through a 200 mesh sieve, and the filtrate is allowed to settle. After scraping off the dark upper layer, the starch is collected, washed, and air-dried.

12.5.3 Physico-Chemical Properties of Rice Starch

Rice has one of the smallest starch granules of the cereal starches, varying in size from 3 to 10μm in the mature grain. Mean granule size varies from 4 to 6 μm. Starch granules of rice are compound, and they are polyhedral or pentagonal dodecahedron. As with other starches, waxy starch granules tend to have lower density than non-waxy granules. Final gelatinization or birefringence end-point temperature (BEPT) of rice starch varies widely among rice varieties and is classified in rice as low (58 °C-69.5 °C), intermediate (70 °C-74 °C), and high (74.5-79 °C).

12.5.4 Uses of Rice Starch

The widespread use of rice starch is currently limited by its higher price relative to corn, wheat, and potato starches. Principal uses of rice starch as (a) a cosmetic dusting powder, (b) a laundry stiffening agent in the cold-starching of fabrics, and (c) a "custard" or pudding starch. In the European Economic Community, rice starch (low-amylose) is used in baby foods, in specific paper and photographic paper powder, and in the laundry industry.

Check Your Progress 4

Note: a) Use the spaces given below for your answers.

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

1. What is the main chemical used in commercial method of starch extraction? Mention its concentration.

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2. What are the important operations in commercial method of starch extraction?

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3. Why do you prefer wet milling than dry milling in commercial method of starch extraction?

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4. What are the operating parameters in commercial method of starch extraction?

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5. What are the important operations in laboratory method of starch extraction?

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6. What is the improved method of laboratory method of starch extraction?

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7. State the reason to use higher alkali concentration in starch extraction.

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8. What is the detergent solution used in starch extraction? Mention its concentration.

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9. What is the concentration of sodium hydroxide to give highest protein extraction of 97%?

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10. Describe ultrasonication for purifying rice starch.

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11. What are the physico-chemical properties of rice starch?

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12. List the principal uses of starch.

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12.6 CANNED RICE

A numerous canned products that contain rice include soups and "dinners", baby foods, plain and flavoured cooked rice, and of course, milky rice pudding. The most suitable varieties for most of these are the long grain high amylose type. The rice should, for preference, have been parboiled. It provides a high degree of grain stability throughout the canning process, which is essential in this product. The most well-known and successful product is canned rice pudding.

Canned rice fall into two categories: **wet pack and dry pack**. A product, in which there is excess of liquid, such as in soup media, is termed wet pack. Proper density is the prime objective with these types of products. The rice is precooked or blanched sufficiently to promote buoyancy in the product and prevent settling and matting. This washing process removes excess surface starch. The rice is put into cans together with the sauce. The cans are sealed under vacuum and then retorted to sterilize the product.

A commercial process has been evaluated for canned white rice packed in 301 x 411 cans with a fill weight of 340 g rice (55-60% moisture) for each can. The initial temperature is 40 °C and the come up time 10-15 minutes. The recommended processing time at 118.3 °C is 55 minutes. The equivalent sterilization value at 121 °C is 13.29 minutes. The variety has a strong influence on the quality of canned rice.

Check Your Progress 5

Note: a) Use the spaces given below for your answers.

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

1. State the reason to use parboiled rice for canning.

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2. What are the canned rice products available in the market?

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3. Describe wet pack canned rice.

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4. Describe commercial process of canning rice.

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12.7 FERMENTATION OF BROKENS FOR ALCOHOL PRODUCTION

Starch is the major constituent of milled rice and makes up 90% of the milled rice in dry weight. Milled rice contains 0.37 to 0.53% total free sugars. Rice is widely used in the world for the production of alcoholic beverages because of its low protein and lipid contents. Rice is the main ingredient, often the sole cereal source, in such beverages as *sake* in Japan, *shaoshin-chu* in China, *Madhu* & *Ruhi* in India and miscellaneous beverages in eastern Asia. Rice is also used as adjunct in the production of other alcoholic beverages, such as beer.

Rice is usually used for brewing in the form of rice grits (or) broken rice, which is obtained as a by-product of rice milling industry. The rice used for beer brewing consists of almost-pure fragments of endosperm that contain starch exclusively.

12.7.1 Indian Madhu

Madhu is a primitive, low-alcohol rice wine in which raw rice soaked in water is the substrate. *Madhu* is a tribal drink produced and consumed primarily in the Nagaland and eastern hill regions of India. It is salted to taste and is used as an early morning meal.

Production: A flow sheet of the production of *Madhu* is given in Figure 12.2. During fermentation, the mixture froths and slight liquefaction of the rice starch occurs.

Microbiological and biochemical changes: Molds of genera *Mucor* and *Rhizopus* are present, together with yeasts and lactic acid bacteria. Some of the starch is hydrolyzed to sugars which are fermented to alcohol and lactic acid. The final pH is 3.8 to 4.5.

Soak 10 kg raw rice in cold water (2hr)

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Drain and grind rice to a paste

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Slurry with hot water

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Add 15 litre cool water and yeast

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Ferment 2-3 days (winter), 1 day (summer)

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Madhu

Fig. 12.2 : Production of Indian *Madhu*

12.7.2 Indian Ruhi

Description and patterns of consumption: *Ruhi* is a strongly alcoholic beverage made by fermentation of boiled rice. It is a special drink produced primarily by tribal people in Nagaland and eastern hill regions of India.

Steps in preparation: A flow sheet of *ruhi* production is given in Figure 12.3. The boiled rice is spread on a mat and after cooling, it is mixed with yeast grown on rice and nosan leaves. The inoculated rice is poured into a cone-shaped bamboo basket and an earthenware pot is placed under the cone to collect the liquefied rice as it ferments. The juice is collected and transferred to new boiled rice about 3 or 4 times in succession. The total liquid collected becomes the first quality *ruhi*.

Microbiological and biochemical changes: The inoculum consists of molds belonging to genera *Rhizpus and Mucor,* as well as yeasts and lactic acid bacteria. Starch is hydrolyzed to sugar which, in turn, is fermented to ethanol. Final ethanol content ranges from 12 to 14% v/v. The pH of the ruhi is about 4.0. Reducing sugars are 2.5% w/v with total sugar being 3.0% w/v.

Boil raw rice
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Drain and spread on mat
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Inoculate with mixed organisms (from rice and nosan leaves)
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Transfer to bamboo basket
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Ferment 24 hr
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Collect fermentation liquor as it is produced in earthenware
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Pot (using funnel)
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Inoculate into boiled, cooled rice Transfer to bamboo basket
↓
Ferment 24 hr collecting fermentation liquor in earthenware pot
↓
Inoculate into boiled, cooled rice
↓
Transfer to bamboo basket
↓
Ferment 24 hr
↓
Collect fermentation liquor in earthenware pot
↓
Ruhi (first quality)

Fig 12.3 : Production of Indian *Ruhi*

12.7.3 Indian Rice Beer-Pachwai

The starter for Indian *pachwai* is bakhar. The bakhar contains *Rhizopus* sp., *Mucor* sp. , and at least one species of yeast. Ginger and other plant materials are dried, ground, and added to rice flour. Water is added to make a thick paste and small round cakes of 1.0 to 1.5 cm in diameter and formed and inoculated with powdered cakes from previous batches. The cakes are then wrapped in leaves, allowed to ferment 3 days, and then sun-dried. *Pachwai* is manufactured by adding powdered bakhar to steamed rice and allowing the mixture to ferment 24 hr. The whole mass is then transferred to earthenware jars, water is added, and fermentation continues. The beer develops a characteristic alcoholic flavor and is ready to drink in 1 or 2 days.

Check Your Progress 6

Note: a) Use the spaces given below for your answers.

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

1. State the reasons to use rice for the production of alcoholic beverages.

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2. What is the main ingredient in production of Indian *ruhi* and Indian *madhu*?

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3. List the alcoholic beverages prepared from rice.

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4. Differentiate microbiology and biochemical changes in Indian *ruhi* and Indian *madhu*.

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5. Explain the process of making Indian beer.

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12.8 IDLI AND DOSA

Idli is a small, white, acid-leavened, and steamed cake made by bacterial fermentation of a thick batter made from carefully washed rice and dehulled black gram dhal. The *idli* cakes are soft, moist, and spongy and have a desirable sour flavor. For *idli,* the rice is coarsely ground and the black gram is finely ground.

Dosa batter is very similar to *idli* batter, except that both the rice and black gram are finely ground. The batter also is thinner than that for *idli*. Following fermentation, the *dosa* is quickly fried as a thin, fairly crisp pan-cake and eaten directly.

Idli and *dosa* are produced primarily in South India and Sri Lanka, but they are known in other parts of India.

Place in Diet and Quantity and Frequency of Consumption

These foods are an important source of protein and calories in the diet and nutrition of South Indians. *Idli* or *dosa* constitute the breakfast of many South Indians, regardless of economic or social status. Because they are easily digested, they are often used as food for infants and invalids.

Idli and/or *dosa* are consumed for breakfast and often for supper in South India. In Sri Lanka, consumption is three or four times per week with the average person consuming two or three dosa at a meal.

Outline of Idli Preparation (Figure 12.4)

1. White polished rice is carefully washed and soaked for 5 to 10 hr.
2. Black gram; dhal is carefully washed and soaked for 5 to 10 hr.
3. The rice is then drained and coarsely ground in a stone mortar or other grinder.
4. The black gram is drained and finely ground in a stone mortar.
5. The rice and black gram slurries are combined to form a rather thick batter which is stirred with the hands.
6. Salt is added to taste. Other seasonings, such as chillies, are occasionally added.
7. The batter is placed in warm place to ferment overnight
8. In the morning, the batter is poured into the cups of an idli steamer which is placed in a covered pan and steamed until the starch is gelatinized and the idli cakes are soft and spongy.

Black gram dhal	White polished rice
Wash and soak 5-10 hours	Wash and soak 5-10 hours
↓	↓
Fine grind in mortar	Coarse grind in mortar
↘	↙

Combine slurries into a thick batter Mix well

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Add salt for seasoning (approximately 1% w/v)

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Incubate overnight in warm place (30-32°C)

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Pour batter into small cups in idli cooker

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Steam 10 minute

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Ready for consumption

Fig. 12.4 : Flow chart of Traditional Indian *Idli* production

Proportion of Water and Salt to Other Ingredients

The amount of water added to the rice and dhal batter is varied from 1.5 to 2.2 times the dry weight of the ingredients. The batter should be made rather thick for idli and much more fluid for dosa. Generally a range of added water varies from 2.0 to 2.2 times the initial dry weights of rice and black-gram. It will thus provide the viscosity desired for dosa. Generally from 0.8 to 1% salt is added to the batter as a seasoning before fermentation.

Fermentation Time

Fermentation times vary from 14 to 24 hr, with overnight being the traditional time interval for idli-dosa. The fermentation time must be sufficient to allow a definite leavening of the batter and allow for development of pleasant acid flavor.

Inoculum

Ordinarily, the microorganisms developing during the initial soak and then during the overnight fermentation are sufficient to leaven idli.

Incubation temperature

Ordinarily, the idli-dosa fermentations are carried out at room temperature. In the tropics, optimum temperature of 25 to 35°C is recommended.

Fermentation Containers

The containers used for soaking the rice and black gram and subsequently for fermenting the batter should be of a sufficient capacity to hold the leavened batter and should be clean to avoid excessive contamination. It is customary to cover the fermentation container with a clean cloth to prevent the entry of insects.

Harvesting and Preservation

Idli and dosa are steamed as soon at the products have become leavened and acidified. They are generally consumed the same day and there is no effort to preserve the products. The acid content retards the growth of food poisoning and food spoilage organisms.

Physical Changes Occurring in Batter during Fermentation

The batter should rise approximately 50% above its original volume, but the batter may rise by as much as three times its original volume.

Biochemical Changes Occurring in Substrate during the Fermentation

In idli made with a 1:1 proportion of rice to black gram, batter volume increased about 47%, 12 to 15 hr after incubation at 30 °C. The pH fell to 4.5 and total acidity rose to 2.8% (as lactic acid) in the same interval.

Nutritive Changes

Fermentation does little to improve the overall nutritive quality. Thiamin and riboflavin increase during fermentation and phytate phosphorous decreases. Fermentation results in an increase in both free and total niacin.

Check Your Progress 7

Note: a) Use the spaces given below for your answers.

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

1. What are the main differences in preparation of *idli* and *dosa*?

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2. Describe outlines of *idli* preparation.

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3. What are the operating parameters in *idli* making?

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4. What are the physical and biochemical changes in substrate during fermentation?

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12.11 LET US SUM UP

Broken rice is the by-product of the rice milling industry, varying between 30 and 50%. Brokens not only reduce the whole grain yield in milling process, but lead to economic loss due to its low selling price. After milling, it is necessary to separate broken kernels and germ from the whole grains for development of various value added products. The brokens mainly used for various types of flours (used for ready-to-eat breakfast cereals, crisped rice, infant cereals, French-fry coatings, powdered sugars, sauces, soups and gravies) and semolina, extraction of starch (used for cosmetic dusting powder, laundry stiffening agent, "custard" or pudding starch, baby foods and specific paper and photographic paper powder), canned rice, as brewing adjunct (wine and beer) and for preparation of breakfast foods, such as *idli, dosa* etc.

12.10 KEY WORDS

Broken Rice : Husked milled or hands produced rice consisting of broken grain or 3/4th of the whole grain but not less than 1/4th.

Germ : A coarse meal made from the sprout, or embryo, found inside the kernel.

Brewer's Rice : Brewer's rice refers to the small pieces of broken rice that remain after the milling process is complete. As the name implies, brewer's rice is often used as ingredient for beer brewing.

Brewing : It is the art and process of making beer.

Glutinous White Rice : It is short-grained, very sticky and chewing rice.

Gelatinization Temperature : The temperature at which starch granules start to swell irreversibly in presence of hot water. It is evidenced by increased translucency and increased viscosity.

Flour : It is the powdery substance made from grinding grains.

Indian *Madhu* : It is a primitive, low alcohol rice wine produced and consumed in the Nagaland and Eastern hill region of India. It is salted to taste and is used as an early morning meal.

Supernatant : The soluble liquid reaction of a sample after centrifugation (or) precipitation of insoluble solids.

Semolina : The word derived from the Latin "simila" means fine white flour. It has a high protein content.

Waxy-rice : (also known as sweet or glutinous rice) is known for its exceptional stability and soft, creamy gel. It is a short and plump with a chalky white, opaque kernel.

12.11 SOME USEFUL REFERENCES

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12.12 ANSWERS TO CHECK YOUR PROGRESS

Check Your Progress 1

1. Relatively cheaper by-product of rice milling industry, broken grains in milled rice varying between 30 and 50%, rice kernels are less than ¾ th of the size of the whole grain, it has low selling price. It is mostly used as feed, brewing adjunct and for preparation of breakfast foods.

2. Pre and post harvest operating conditions of paddy. Paddy variety has some effect on broken yield and type of milling machinery used also has effect on the broken yield.

3. Permissible limit of brokens generally vary between 18 and 25% of the total weight of the lot.

4. High capacity grading sifter, indented cylinder grader, colour and optical sorters.

5. Grading of rice kernels and the foreign objects on the basis of appearance or reflection of light to the specific sensor.

6. Rice kernels fall at a specific speed through camera, camera gathers light, photo-electrical sensor and trigger mechanism is activated, microprocessor electromagnetic valve operates with the compressed air blast line open.

Check Your Progress 2

1. Rice germ is embryo-the rudimentary form of future plant. It is very small. It is located ventral side of the caryopsis. Germs are almost 2 to 3% wt.of brown rice. Its protein efficiency ratio is around 2.59, while biological value is 78. The embryo contain 7.4% pentosans, 4% cellulose, 3 to 6% lignin, 11.6% reducing sugar, 2.1% non reducing sugar, 0.8% phytin phosphorous-4.6% free amino acids.

2. Laboratory-level separator, pneumatic separator and degermer.

3. Brown rice is fed into the perforated chamber, germ is removed due to friction caused between the grains. Germ recovery varies from 90 to 95%

4. Mesh: 0.8mm ϕ, 1.5mm ϕ and 2mm ϕ

Check Your Progress 3

1. In wheat industry- milling produces flour, semolina etc.

   In rice milling industry- milling refers removal of bran for producing polished rice, and grinding brokens or polished rice produces rice flour.

2. Traditional Asian foods and baked goods, gluten free rice bread, baby foods, breakfast cereals and snack foods, unbaked biscuits, dusting powders and breading mixes, formulation of pan cakes and waffles.

3. Glutinous rice flour is used for oriented snack foods, thickening agent in whitesauces, gravies, puddings, frozen foods.

   Non glutinous rice flour is used to improve crispiness in crackers, as a thickener in soups and gravies, carrier for flavours and seasonings, and binding agent in meat products and rice pasta formulations.

4. Rice flour does not contain gluten. Its dough does not retain gases generated during baking.

   Wheat flour contains gluten. It provides elasticity in the dough to allow retention of CO2 gas generated during bread making process.

5. Ready-to-eat breakfast cereals, crisped rice for candies and snacks, infant cereals, French-fry coatings, extender in powdered cheeses and powdered sugars, waffle and pancake mixes and sauces, soups and gravies

6. Rice flour chips absorb less fat during frying, less breakage

7. Viscosity, starch gelatinization temperature, birefringence end point temperature, and water absorption capacity are the properties to measure the characteristics of rice flour.

8. Methods are wet, semidry, and dry milling.
   Main unit operations include soaking, milling, drying and regrinding.

9. Rice soaked in water for 4 hours, drained, and ground by a stone mill. Excess water is removed by drying and the flour is gently regrinding.

   Its uses are for making Japanese cake, rice crackers, Taiwanese cakes, rice noodles, Filipino rice cakes and Indian fermented foods such as idli, dosa etc

10. Advantages cleaned rice can be ground to different sizes without generating waste Water. The product so obtained has same protein content. Disadvantages more starch damage.

11. Baked products, baby foods, extrusion cooked products and in high protein flour.

12. Nutritional supplement in baby foods, instant milk, gruel, and puddings.

13. Different flavour and chewy texture, limited shelf life, rancidity problem.

Check Your Progress 4

1. 0.3-0.5% sodium hydroxide

2. Steeping broken rice, wet milling, removal of cell walls, extraction of protein, washing and drying.

3. Starch damage is more in dry milling, resulting great starch losses.

4. Steeping broken rice is done in 0.3-0.5% sodium hydroxide solution at room temperature to 50^0C for 24 hrs.

5. Steeping milled or broken rice in 5-6 volumes of 0.2-0.3% sodium hydroxide-steep liquor drain off- endosperms pressed and ground-slurry diluted to original volume-mixture stirring and overnight settlement-cloudy supernatant drained off-sediment diluted to original volume-starch suspended in water and passed through mesh-starch collection by sedimentation or centrifugation.

6. Homogenizations of steeped grain in a waring blender and passing the resultant mixture through a mesh before sodium hydroxide treatment and continuous shaking for 3-6 h.

7. Lower alkali concentrations are ineffective for complete extraction of proteins and starch lipids.

8. 1-2 % dodecyl benzene sulfonate.

9. 0.4 % sodium hydroxide.

10. 5g of milled rice powder suspended in 45 ml of distilled water, subjected to stirring at 10 kHz for 10-20 min, homogenate filtration, scrapping off dark upper layer, starch collection, washing and drying.

11. Size of starch granule varying from 3 to 10 μm, starch granules are compound, polyhedral or pentagonal dodecahedron, lower density, birefringence end-point

12. Cosmetic dusting powder, laundry stiffening agent, "custard" or pudding starch, baby foods, specific paper and photographic paper powder.

Check Your Progress 5

1. High degree of grain stability throughout the canning process.

2. Soups and "dinners", baby foods, plain and flavoured cooked rice, milky rice pudding.

3. Rice is precooked or blanched, washing, rice is put into cans, sealing is done under vacuum, retorted to sterilize the product.

4. The initial temperature is 40 °C for 10-15 minutes. The recommended processing time at 118.3 °C is 55 minutes. The sterilization temperature at 121 °C is 13.29 minutes.

Check Your Progress 6

1. Rice contains low protein and lipid which favours the fermentation process.

2. Indian Madhu- raw rice

   Indian Ruhi- boiled rice

3. Sake in Japan, Shaoshin-chu in china, Madhu, Ruhi, Rice Beer in India.

4. Indian Madhu - Molds of genera Mucor and Rhizopus, final pH-3.8-4.5.

   Indian Ruhi- Molds of genera Mucor and Rhizopus, final pH-4.0, reducing sugars-2.5%, total sugar-3.0%.

5. Mixing of rice flour and ginger plant powder, addition of water, formation of small round cakes, inoculation, wrapped with leaves, fermentation, sun drying.

Check Your Progress 7

1. Idli- washed rice (coarse grinding) and dehulled black gram dhal (fine grounding)- white, acid leavened, and steamed cake

   Dosa- rice and black gram dhal are finely ground- fried as thin, fairly crisp pancake.

2. Polished rice and black gram dhal are washed and soaked in clean water. Washed rice and dehulled black gram dhal (fine grounding) are mixed along with water to make thick batter. Addition of salt and allow for fermentation, vary from 14 to 24 h, batter is poured in idli cups, then steaming, and the idli cakes.

3. 1.5 to 2.2 times dry weight of ingredients, fermentation time of 14 to 24 hrs, incubation temperature of 25 to 35 °C.

4. Batter should rise 50% above its volume, pH 4.5 and total acidity 2.8%.