UNIT 13 RICE BRAN

Structure

13.0 OBJECTIVES

After reading this unit, you should be able to:

- understand importance of rice bran as a by-product of rice milling industry;
- explain composition and properties of rice bran;
- know about processing of rice bran for protein extraction;
- explain extraction, refining and use of rice bran oil for human consumption; and
- describe the importance of rice bran as animal feed and as human food.

13.1 INTRODUCTION

Bran is the hard outer layer of cereal grains, and consists of combined aleurone and pericarp. Along with germ, it is an integral part of whole grains, and is often produced as a by-product of milling in the production of refined grains. When bran is removed from grains, they lose a portion of their nutritional value. Bran is present in grains and may be milled from any cereal grain, including rice, wheat, maize, oats, and millet.

Bran is particularly rich in dietary fiber, and contains significant quantitities of starch, protein, fat, vitamins, and dietary minerals.

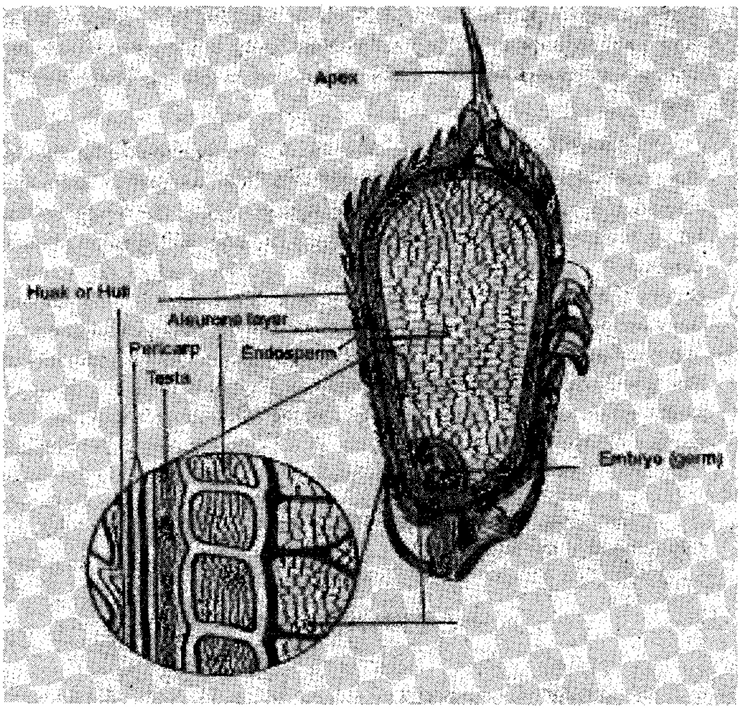


Fig. 13.1: Longitudinal section of a paddy grain

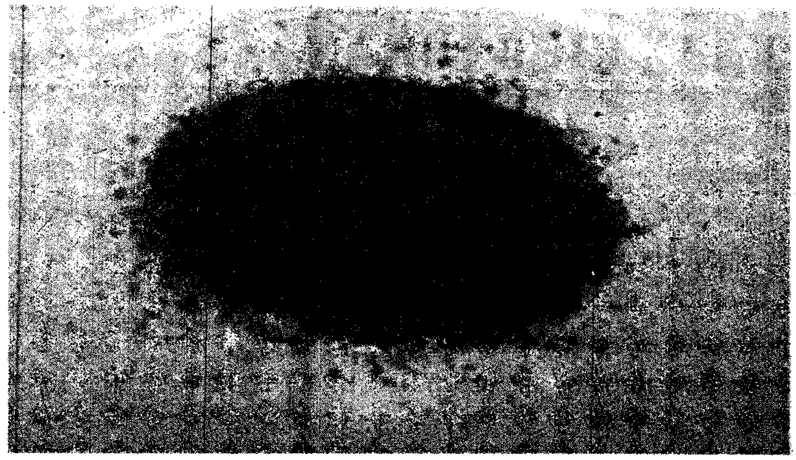


Fig. 13.2: Rice Bran

Bran is often used to enrich breads (notably muffins) and breakfast cereals, especially for the benefit of those wishing to increase their intake of dietary fiber.

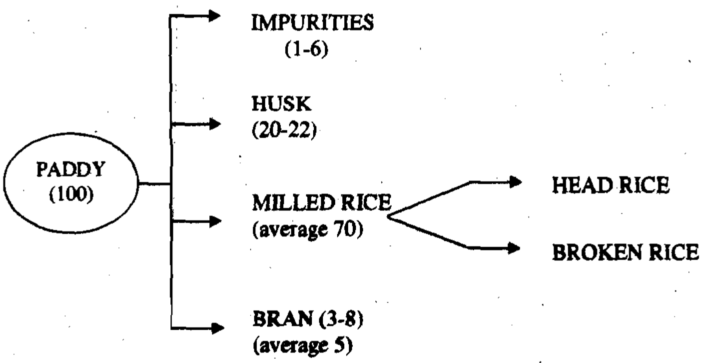
Rice bran (Fig. 13.2) finds particularly many uses in Japan, where it is known as ***nuka***. Besides using it for pickling, Japanese people also add it to the water when boiling bamboo shoots, and use it for dish washing. In Kitakyushu City, it is called *Jinda* and used for stewing fish, such as sardine.

Rice bran is a by-product of the rice milling process, and it contains various antioxidants that impart beneficial effects on human health. It is well known that a major rice bran fraction contains 15%-20% oil and highly unsaponifiable components (4.3%). This fraction contains tocotrienol, gamma-oryzanol, and squalene. All these constituents may contribute to the lowering of the plasma levels of the various parameters of the lipid profile. Rice bran also contains a high level of dietary fibers (beta-glucan, pectin, and gum). In addition, it also contains 4-hydroxy-3-methoxycinnamic acid (ferulic acid), which may also be a component of the structure of non-lignified cell walls.

The high oil content of bran renders it to rancidification, one of the reasons that it is often separated from the grain before storage or further processing. The bran itself can be heat-treated to increase its storage life.

The amount of bran removed is called the degree of milling, that is, the percentage weight of brown rice removed. To get completely white and shining rice, it is necessary to remove 9% or more of the weight of the brown rice as bran (9% degree of milling). However, samples sold in the market generally contain much higher polish, at least of the order of 6-8%. We can therefore say in general that the amount of bran obtained in India is approximately 6-7 Kg. for evey quintal of brown rice polished. Considering that paddy as purchased contains some impurities/driage, a quintal of paddy yields about 76 Kg. of brown rice. We can therefore say that the amount of bran obtained is approximately 4.5-5% of paddy, that is, about 5 Kg. bran for every quntal of paddy milled.

The yield of various products and by-products from paddy is summarised below:



Husk, bran and broken rice are thus the three by-products of rice milling. For the health of any industry, utlization of its by-products is most imporant. Fortunately, all the three are valuable materials and have many uses. The properties and uses of bran are discussed here.

13.2 COMPOSITION AND PROPERTIES OF RICE BRAN

Types of Bran

The nature and composition of the bran obtained from rice depends on the system of milling and on any pretreatment given to the paddy. Accordingly, the following variables affect the bran:

Huller versus disc sheller versus rubber roll sheller mills,

Abrasion versus friction-type polishers,

The stage of polishing,

The degree of Milling,

'Polish" versus bran,

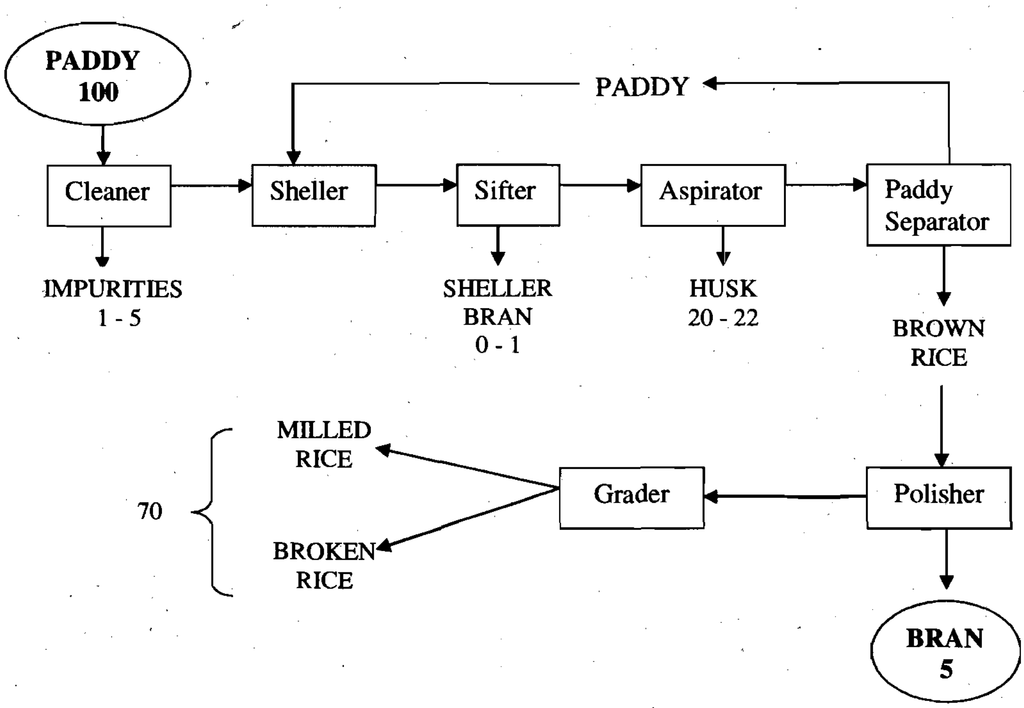
Whether germ is separated from the bran, and

Bran from parboiled or raw rice.

When paddy is milled by single hullers (or by hand-pounding), a mixture of powdered husk and true bran is obtained. As a result, this bran contains very low amounts of oil and protein and high amounts of fibre (undigestable matter) and ash. It has very little industrial value.

When paddy is milled in sheller mills, it is first dehusked either in an under-runner disc sheller or in a rubber roll sheller and then polished in a polisher. A flow-sheet of the milling operation is shown below:

Flow sheet of the milling operation



A small amount of powdered material is obtained during dehusking (shelling) which is called 'sheller bran'. The sheller bran from under-runner sheller is fair in amount and also contains some true bran and germ, in this system the dehusked brown rice has to pass over a large surface of emery and is thereby scratched to some extent. The amount of oil and protein in it is too small to be of industrial value. The sheller bran obtained after rubber-roll shelling contains very little true bran or germ and is mostly composed of powdered hulls and dust and has only fuel value.

The main rice bran of industrial importance is the true bran, that is, the outer layers of brown rice separated during its polishing. Here again two types of polishers are used, namely, the abrasion type (emery type) and friction type (metal type). In abrasion type polishers, the bran is cut out in small pieces from the grain surface by the sharp emergy particles. As a result the bran also contains some endosperm (inner grain) matter. In friction type polishers, bran is removed in slightly larger pieces due to rubbing of the grains among themselves under pressure. So it contains less endosperm material and consequently a little more oil, protein and ash than bran from abrasive polishers.

Bran composition changes slightly with the stage of polishing. When the dehusked rice is polished in more than one polisher, oil, fibre and ash contents gradually decrease while starch gradually increases from the first to the last polisher. However, these differences are not important from the industrial standpoint and bran from different polishers are normally mixed together.

Presence or absence of germ in bran changes its composition slightly. The rice germ normally gets separated in stages during polishing of dehusked rice and gets mixed with bran. Rice bran as obtained from rice mills therefore includes rice germ (about 2% by weight). However, the germ is separated from bran by sieving and aspiration in the milling systems of some European countries (Spain, Italy). In this case the bran composition changed to some extent; especially the oil content is decreased.

Previous processing of rice, especially parboiling, changes bran composition and properties. This aspect is discussed in the next section. Heat treatment of bran for stabilization causes very little change in its composition and properties. But there is a partial agglomeration of bran and destruction of some enzymes.

In European and US mills, after removing the bran (whitening) in cone or horizontal polishers, rice is subjected to what is called 'polishing' operation in special equipments. In these 'polishers', rice is rubbed by leather straps instead of by emergy. The idea is to remove all loose bran particles and a bit of the endosperm so as to give the rice a good shine. The material removed at this stage is called'polish'. In composition, 'polish' is intermediate between bran and endosperm. Oil, protein, fibre, ash and vitamins in 'polish' are less than in bran but more than in endosperm. It should be noted that in India such 'polishers' are not used, and whitening itself is generally called polishing. So the terms 'polishers' and 'polishing' as used in India should not be mixed up with the same terms used in European and US writings.

Composition of Rice Bran

The range of compositions of rice bran (excluding huller mill bran and 'sheller bran') is shown in Table 13.1. These data relate to bran from raw rice. If rice is parboiled, the aleurone layers of the grain are broken up by parboiling and the oil is pushed outward. Therefore more of the oil comes into bran during milling. On the other hand, some of the vitamins and minerals in the outer layers are retained in the milled rice after parboiling, so that bran from parboiled rice contains less vitamins and minerals.

Carbohydrates (nitrogen-free extract) constitute some 30-50% of bran. They consist of varying amounts of starch (depending on how much of endosperm is polished), free sugars, cellulose and hemicellulose. Bran also contains some lignin. Cellulose, hemicellulose and lignin are parts of 'fibre' and are indigestable.

On an average rice bran contains about 15% protein. Non-protein nitrogen accounts for about 16% of total nitrogen; most of it is in the form of free amino acids. Proteins are of many kinds, depending on, in what medium they can be dissolved, namely:

albumin	-	soluble in water,
globulin	-	soluble in salt solution,
prolamin	-	soluble in alcohol, and
glutelin	-	not soluble in anything.

Rice protein consists mostly of insoluble glutelin (about 80%) and of only small amounts of *albumin*,

Globulin predominate in the outer layers of brown rice. As a result, protein composition in the bran is quite different from that in milled rice and consists mainly of albumin, globulin and small amounts of prolamin and glutelin. The comparative compositions of bran, rice and germ proteins are shown in the figure below. As albumin and globulin contain more lysine than glutelin, the lysine content of rice bran is more than that of whole rice grain (Lysine is an amino acid. Several amino acids join together to form a protein. Some 20 amino acids are found. Lysine is low in rice and in all other cereal proteins).

Table 13.1 : Chemical composition of rice bran and germ

Constituent	**Unit**	**Range of values in**	
		Bran	**Germ**
Protein	%	12 - 17	15 - 25
Fat (oil)	%	13 - 23	17 - 40
Carbohydrates	%	34 - 54	35 - 42
Starch	%	10 - 25	2 - 4
Free sugars	%	3 - 7	8 -12
Pentosans	%	5 - 8	5 - 7
Hemicellulose	%	9 - 17	9 -15
Cellulose	%	5 -10	3 - 7
Lignin	%	3 - 10	1 - 5
Crude Fibre	%	6 - 14	2 - 10
Ash	%	7 - 15	5 - 11
Phosphorus	%	1 - 3	1 - 3
Potassium	%	1 - 2.5	1 - 2
Magnesium	%	0.5 - 1.3	0.4 - 1.5
Silica	%	0.5 - 1.5	-
Calcium	mg/100 gm	30 - 130	20 - 100
Iron	mg/100 gm	9 - 50	10 - 50
Vitamins			
B1 (Thiamine)	mg/100 gm	1.2 - 3.0	4 - 8
B2 (Riboflavin)	mg/100 gm	0.2 - 0.4	0.2 - 0.5
Nicotinic acid	mg/100 gm	25. - 50	2 - 10
E (Tocopherol)	mg/100 gm	2.5 - 13	8 - 10

There is a large variation in the gross chemical composition of Rice Bran (Table 13.2)

Table 13.2 : Variation of gross chemical composition of rice bran

Constituent	Minimum (% dry basis)	Maximum (% dry basis)
Protein	11.5	17.2
Fat	12.8	22.6
Fibre	6.2	14.4
Ash	8.0	17.7
Nitrogen Free Extract (NFE)	33.5	53.5

As the rice grain is a living seed, it contains many enzyme systems located mostly in the germ and aleurone layer (enzymes are what make chemical reactions go on in a living cell). Most of these enzymes come into the bran after milling. Hence, rice bran is rich in various enzymes. While other enzymes are not of much industrial importance, the presence of lipase in bran is of great importance, as will be discussed later. Most rice enzymes are destroyed during parboiling, hence bran from parboiled rice contains little or no enzymes.

Rice bran contains relatively large amounts of minerals as can be seen from its high ash content (Table 13.2). Among the minerals, the predominant component is phosphorus. It amounts upto 3% in bran. The other important minerals are potassium, magnesium and silicon. Calcium and iron, two important nutrients, are rather low. The content of minerals in bran increases first as rice is polished and then decreases with further polish. About 90% of the phosphorus is present in the form of phytin. This is important from the standpoint of nutrition, for phytin is rather harmful as will be discussed later.

Rice bran contains high levels of B vitamins (see Table 13.2). This is because most of the vitamins in raw rice is located in the outer layers, which are therefore removed into the bran during milling.

As explained earlier, much of the vitamins and minerals are retained in the milled grain after parboiling and accordingly bran from parboiled rice contains much less vitamins and minerals.

How does rice bran is compenable with brans from other cereals? Other brans generally do not contain germ, while rice bran usually includes the germ. This is one reason why the fat (oil) content of rice bran is much more than bran from other sources. Protein and fibre content of rice bran are similar to those of other brans. But rice bran is richer in ash, especially silica, and also in phosphorus, 90% of which is in the form of phytin which is the highest among all cereal brans.

The amino acid composition of rice bran is by far better than those of other brans. Bran protein is richer in lysine than that of whole rice, for it contains more of albumin and globulin (which contain more lysine than glutelin) than in the total grain. For this reason, the nutritive value of rice bran protein is more than that of other bran proteins. However lysine and threonine are still the limiting amino acids in rice bran as in other bran proteins.

Properties of Rice Bran

The particle size distribution of bran varies depending on its source. Friction type polishers produce bran of larger particle size than abrasion type polishers. In polishing cones the percentage of fine particles tends to increase with successive cones. Heat stabilization tends to bring about agglomeration of rice bran particles. Bran from parboiled rice is flakier with larger particle size than bran from raw rice. The germ in rice bran is generally bigger in size than its other components.

The bulk density (weight per volume of bran in bulk) of rice bran is very low (Table-13.3). But the true density (weight per volume of each bran particle) is close to that of milled rice. Its angle of repose (angle formed by a heap) is about the same as that of rice and paddy. Its equilibrium moisture content (moisture content attained when exposed to air) is about 2% less than that of milled rice. The highest safe moisture content for its storage is 10-12%.

Table 13.3 : Some properties of rice bran

Property	Bran	Germ	Milled Rice
Bulk density (gm/cc)	0.2 - 0.4	0.5	0.8
True density (gm/cc)	1.2 - 1.3	-	1.45
Angle of repose (degree)	38	-	38
Equilibrium moisture at			
75% RH (% wet besis)	12	-	14

13.3 USE OF RICE BRAN AS ANIMAL FEED AND AS HUMAN FOOD

It is evident that bran is a very valuable product for many applications as illustrated in Fig.13.3

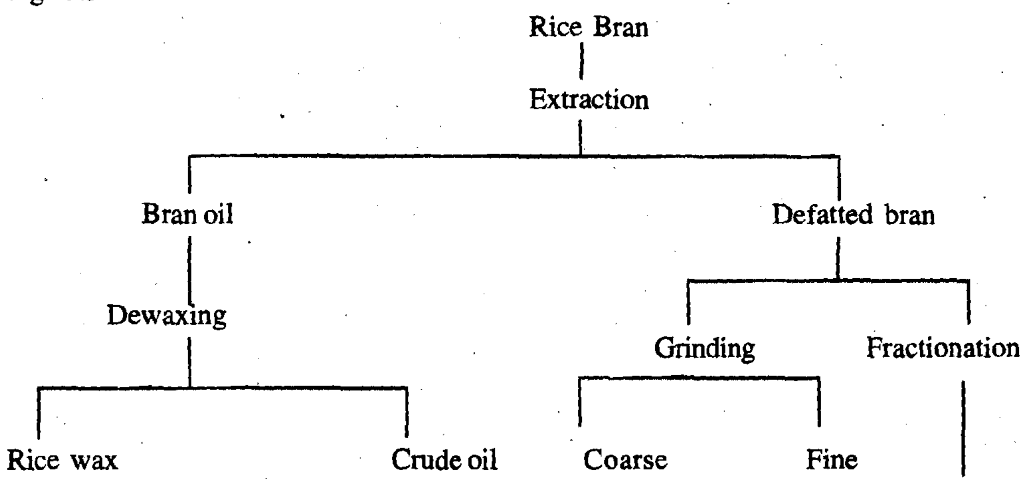


Fig. 13.3 : Products of bran

Nutritional Value of Rice Bran

The protein content of bran is around 15%, which clearly puts rice bran as an important source of protein. The protein goes up further in deoiled bran (17-20%). The amino acid composition of rice bran protein compares favourably with those of other cereal brans, oilseeds and even cereal grains including wheat and maize. The chemical score of the protein as per the FAO/WHO reference pattern is 80% for first limiting amino acid level (lysine) and 90% for the second limiting amino acid level (threonine). Another method of measuring the nutritive value of a protein is by feeding it to young rats and measuring the 'protein efficiency ratio' (PER), that is, the gain in rat's weight in gram per gram of protein eaten. The PER of rice bran protein is around 1.8-1.9; that of germ protein is slightly higher (2.0). These values compare favourably with those of grains like wheat (1.0), maize (1.2), groundnut (1.7) and rice (1.9); cow's milk has a PER of 2.5 and egg 3.8. However, the digestibility of the protein (in the rat) is not very good. This is caused by the high amounts of fibre and phytin in bran and by the fact that most of the protein is in the form of protein bodies.

Digestibility of bran organic matter (protein, lipids and carbohydrates) is good, in sheep, although low in the case of fibre. Defatting improves digestibility. Hence, the final nutritional value as well as the calorific value of the defatted bran is nearly the same as that of original full-fat bran (for sheep). Presence of husk in bran reduces digestibility. Digestibility of hulls for non-ruminants is practically zero, although some hulls are customarily fed to poultry. The amount of total digestible nutrients in bran is higher than that in wheat bran and is quite comparable to wheat endosperm and oats.

It is needless to say that full-fat bran is a good source of calories as well as essential fatty acids as it contains so much oil.

Rice bran is an excellent source of B vitamins and vitamin E. Contents of these vitamins are reduced in bran from parboiled rice because the vitamins are partly retained in the milled rice when parboiled.

The minerals in bran and their role in nutrition are discussed below.

13.4 PROCESSING OF BRAN FOR PROTEIN

Since the protein content of rice bran is higher than any other portion of the rice kernel, full-fat, stabilized full-fat or defatted bran can be effectively utilized for production of high-protein flour or protein concentrate which can be used as food-grade material. Technology of processes from production of these materials to be used in bread and other bakery products in admixture with wheat flour is being developed in some countries. Some of the processes have come up to the pilot plant stage also.

Utilization of full-fat bran for edible purpose is, however, limited by two major drawbacks: instability and high fibre content. Satisfactory bran stabilization methods are available but fibre still remains as the major problem, because it affects (a) palatability, (b) availability of nutrients and (c) the functional properties of the whole product.

Fractionation of bran can isolate the protein and thereby solve the problem by decreasing the fibre.

The process of fractionation may be divided into two categories: (1) Dry methods based on segregating portions of the bran by grinding, sieving or air-classification, and (2) Wet methods based mostly on the solubility of rice bran protein in water or in alkaline medium. High-quality protein concentrates can be prepared by this method.

Dry method – The first attempt on grinding and sieving at 40-mesh yielded about 30 per cent as refined bran, which contained 14 per cent crude fibre and could be used as feed for non-ruminant. Another product was obtained by sieving through a 100-mesh screen and contained 12 per cent protein and only 5 per cent crude fibre. It could be used as food ingredient.

A three-stage process consists of screening in a 20-mesh sieve, grinding the fines in a flour mill and screening through 75-mesh sieve and final screening through a set of sieves (80, 100, 140 and 200 mesh). The product – 140 mesh is ¼ the original bran and contains 15-16 percent ash and 1-1.5 per cent fat.

Wet methods – Water extraction method consists of soaking rice bran in water under controlled conditions, grinding the soaked bran and screening to remove the fibres. The particle-size of bran is the key factor in separation of the components. Grinding in disc, rotary or colloid meals have been found to be effective. Screens, hydroclones or a combination of these are employed to remove the fibres. The fractions are dewatered by centrifuge and dried. A latest fractionation process yielded three fractions:

(a) a high-protein low fibre flour, approximately 60 per cent by weight,

(b) a high-fibre protein meal, 30 per cent by weight and

(c) a fraction rich in sugars, vitamins and minerals, 10 per cent by weight.

Results showed that the low-fibre fraction has the high food potential and the high-fibre has a good food-value.

Alkali extraction method – Defatted bran is extracted with aqueous alkali at room temperature at pH 11 followed by precipitation of solids by reducing pH to 5.5 with hydrochloric acid, centrifuging and drying. A 94-99 per cent protein concentrate, which is 30 - 40 per cent of the original total protein. A pilot plant two-stage alkaline extraction sieved a 75 per cent concentrate whose limiting lysine content was 4.11 per cent based on the total protein.

Anti-Nutritional Factors in Bran

Rice bran contains some anti-nutritional factors, although most of these are only of minor significance.

Phytin is the most important factor 90% of bran phosphorus exists in the form of phytin. It is located in the protein bodies of the aleurone. The phosphate groups of phytin get complexed with calcium, iron and zinc, which are already low, and also with protein, and tend to render them unavailable for nutrition. Rice bran contains the highest amount of phytin among all cereal brans. When incorporated as fibre at 6% level in chick diet, only rice bran among various brans reduces growth and bone deposition.

Calcium/phosphorus and phytin/zinc ratios are important in nutrition. A ratio of 1/2 to 2 of the former is desirable but it is less than 0.1 in rice bran (but the ratio is equally low in other grain brans as well). Phytin/zinc molar ratio of over 10-15 depresses growth in rats. But this molar ratio is around 30-40 in rice bran (also in other grain brans). On the other hand, increasing the calcium content in bran by adding calcium carbonate (for example to help in polishing of brown rice) depresses bioavailability of zinc.

Trypsin inhibitor is a toxic factor present in rice bran in small quantities. It is easily inactivated by steaming, although not by dry heat. It is an albumin and is present mostly in the germ.

Hemagglutinin is another toxic factor and is a globulin. A similar factor is lectin which is a glycoprotein. All these are easily destroyed by heat.

Dietary fibre, which is high in bran, can also act as an anti-nutritional factor in excessive amounts. The amount of dietary fibre as determined by enzymatic and biological methods is about four times that of the chemically determined crude fibre. Excessive fibre decreases digestibility of nitrogen and also binds some minerals like calcium and iron. Highly pigmented rice varieties contain some tannins in the bran layer, which also binds nutrients.

Use of Rice Bran for Human Food

Use of rice bran as a possible food ingredient has been long thought of Dr. Salvadoe Barder of Spain in a review article in 1974 wrote "everything would indicate that the possibility of using rice bran as food is imminent". This possibility is being realized now.

It has been reported that the carbohydrate fraction of rice bran contains nutritionally important dietary fibre which has hypo cholesteremic, hypoglycemic and laxative properties. In fact, these properties of rice bran are next only to that of oat bran among all cereal brans. Food uses of rice bran have been explored in other countries in which both full fat and deoiled bran form has been used in baby foods, breads, muffins, pancakes, cookies, cakes, pies, coatings and crusts for finger foods, confectionery, spice carriers, deep fried preparations, extruded snacks and breakfast cereal. Recently processed bran have also appeared in western markets for use as additive and source of dietary fibre in various foods at home.

The Rice Millers Association of USA adopted a definition and minimum standard for full-fat stabilized raw and parboiled rice bran for food uses.

Protein concentrates obtained from bran as described below have the potential of being possibly used in various products. Milk-like or beverage-like products have been made from bran either by water extraction of full-fat bran or from the concentrates mentioned.

The functional properties of rice bran proteins should be of major importance in possible use of bran proteins in food formulations. But such functional properties of bran proteins (solubility, water absorption, emulsification, fat absorption, viscogenicity, foaming) have not been extensively studied yet.

Edible Fractions from Bran

The utilization of bran for food is limited by two main factors: its instability and its high fibre content. The instability aspect has been now largely solved by development of stabilization processes. Attempts have been made to reduce the fibre content as well as to increase the concentration of other nutrients by various fractionation procedures.

Attempts at dry fractionation of rice bran either by sieving or by air classification with or without further grinding with the aim to obtain a nutrient-rich fraction but with less fibre has not been very successful.

Some success has been achieved with wet fractionation systems. Both alkaline extraction and water extraction have been tried.

Solubility of bran proteins increases with increasing pH (that is, alkaline). This is the basis of two or three systems in which rice bran is extracted with dilute alkali at a pH ranging from 9-11.5. The solution is separated by centrifugation. The protein is then precipitated with acid at the isoelectric pH of about 4-4.5. Some more protein can be recovered from the solution by coagulating with heat. The material is dried in a drum dryer. Protein concentrates having upto 85% protein can be obtained in this way, recovering upto 50% of the bran protein. The concentrate has essentially the same amino acid composition as in the original bran and good PER value.

In an alternative approach, rice bran suitably ground in dry or wet state is extracted with water. The slurry is either decanted or screened to remove the fibre. Suitable treatments of heating, centrifugation and screening can give three fractions: a high-fibre (18%) intermediate-protein (13%) residue, a low-fibre (less than 3%) higher-protein fraction (16-20% protein), and a syrup containing the water soluble vitamins and other nutrients. The second fraction can be used in food and the first in feed.

While these attempts have shown the potential of obtaining high value fractions from rice bran, their use in food remains to be achieved.

Use of Rice Bran as Animal Feed

Use of rice bran in composite feeds has the following limitations: (1) high amounts of fibre, (2) high amounts of unsaturated fat, (3) presence of calcium and phosphorus in undesirable proportions, (4) high amounts of phytin, (5) sometimes too much sand and silica, (6) variable composition, and (7) high instability.

The dry matter of ration for an animal with a single stomach (non-ruminants) should not contain more than 6% fibre, but the fibre content of ruminants may be as high as 35%. For this reason bran cannot be used in unlimited quantities in single-stomach animals.

The high unsaturated oil content of bran prevents its use in unlimited proportion in animal rations. The body fat, for instance in pigs, is thereby affected and becomes too soft. But deoiled bran, naturally, does not cause this problem.

The problem caused by the calcium/phosphorus ratio and phytin have already been discussed. Similarly the amount of sand and silica in compound feeds should not be more than 4%, but rice bran that has been made or handled improperly often has more.

In industrial manufacture of balanced feed, too much variation in the composition of a raw material, as is common in rice bran, is quite undesirable.

Chemical instability of bran is another factor. Fat hydrolysis develops FFA (free fatty acids), while oxidation may lead to undesirable compounds as well as bitter taste. Deoiling of bran leads to greater stability. Heat stabilization prevents FFA development and also helps in reducing the activity of micro-organisms and other pathogenic and/or toxic factors in rice bran.

Rice bran is used satisfactorily in pig diets, upto 20-40% in the ration. Upto 40-50% bran can be used in the diet of poultry. However use of unstabilized bran in poultry feed is risky, for unsaturated acids in the process of becoming rancid may lead to loss of tocopherols and hence to vitamin E deficiency. Upto 60% bran can be used in the ratio of dairy cows.

13.5 EXTRACTION, REFINING AND USE OF RICE BRAN OIL

Pressing

As the oil content of rice bran is rather low, oil cannot be easily prepared from bran by pressing. However, pressing was a common practice in Japan in olden times (before World War II) and has also been practiced in China, Vietnam and Thailand. The process in Japan involved steam cooking of bran at a pressure of 4-5 kg/cm^2 and then drying. Bran was then prepressed at a pressure of 70 kg/cm^2 followed by ring or cage hydraulic pressing at a very high pressure (100-1000 kg/cm^2). Continuous expellers at still higher pressures were also used. A little over half the bran oil can be pressed out by these methods. One advantage is that the crude oil is of purer quality than that obtained by solvent extraction.

This method of bran oil preparation has been now totally given up in Japan and is planned to be gradually replaced by some new process in China and Vietnam.

Solvent Extraction

Solvent extraction has the advantage that it can recover almost the entire amount of oil in the bran (residual oil in bran, 1-1.5%). But it has the disadvantage of extracting many impurities and colour so that refining of the oil is more expensive. The methods largely follow the conventional extraction and refining technologies. However, one should note that the oil content of bran is not very high, 12-25%, and the material is powdery. Also the oil contains certain special compounds. Hence, some modifications of the standard technology are adopted.

Extraction can be of batch, battery or continuous type. The batch and battery systems are generally used in Japan. Continuous extraction plants have larger capacity and are being operated in many places (India, Burma, Egypt, Mexico, Taiwan and Thailand).

Batch extraction is the oldest system. The pretreated bran is placed in one or more extractors, Hexane is pumped in and the solvent level is maintained to percolate the bran and extract the oil. The miscella (mixture of oil and solvent) is passed through a filter to an evaporator for desolventizing.

In battery extraction, several extractors are arranged in series, and miscella obtained from one is passed through the other extractors one after the other in a counter-current system. Fresh solvent is applied only to the last extractors. This is a semi-continuous system.

Continuous extraction achieves the highest economy in steam, power, labour and material but is more sophisticated and is suitable only when the capacity is atleast 50 tonnes per day. It uses the counter-current principle and is either of immersion or percolation type. A filtration-extraction process is also used. The plants commonly used include De Smet type from Belgium, rotating O-W type from Japan, Lurgi type from Germany and Rosedown type from England.

While in the batch or battery system bran as such can generally be used, its pelletization is essential in the continuous system. This is necessary to reduce the problem of channeling in extraction and of fines which clog the filters as well as pass through the filters to make the oil turbid. To prevent this, bran is made into pellets of 6-8 mm size. Stabilization by moist heating causes agglomeration of bran in which case pelletization may not be required. Stabilization of bran by extrusion cooking produces flakes, in which case pelletization is unnecessary. In batch plants, where pelletization is not essential, some processors add coarse husk to help extraction; the husk is later on removed from the dry deoiled bran by sieving.

Although hexane is the solvent of choice and has been universally applied in solvent extraction, other solvents may have some special advantages. Ethyl or isopropyl alcohol have been tried. These have the advantage of extracting less wax, which means dewaxing problem is eliminated, and of extracting sugars and B vitamins which can be recovered as a by-product syrup. However, alcohol extracts more colour, causing difficulty in bleaching, and reduces the nutritive value of the extracted bran by dissolving the B vitamins.

Parboiled bran contains more oil and should therefore be a preferred material for extraction. However, processors have sometimes reported problems with it. First, parboiled bran is more difficult to pelletize and may require some special conditions. To overcome this problem, some processors mix raw bran with parboiled bran, which however causes FFA (free fatty acids) problem. Second, predrying of parboiled bran is essential for batch extraction. Third, parboiled bran needs a longer time and more number of extractions to extract all its oil. In batch extractors parboiled bran needs at least three solvent washings to recover all oil. Finally, improper parboiling may darken the oil colour.

Refining of Rice Bran Oil

In India, rice bran oil has only recently begun to be used as cooking oil. As far as food use is concerned, so far it has been used only for making Vanaspati, for which purpose oil with less than 8-10% FFA is considered acceptable and this oil is called 'edible rice bran oil' in the trade. Genuine edible-grade oil to be used for cooking/salad oil requires refining.

Other vegetable oils are generally prepared in India by pressing and can be directly used in food. But rice bran oil is prepared by solvent extraction and as such it has to be refined for use in cooking. Refining is also necessary in view of the presence of acids in it. Even if the oil is prepared from fresh or stabilized bran, the amount of FFA in the oil is usually more than 3%, making it generally unsuitable for direct use in food.

Refining of rice bran oil is more difficult than other vegetable oils due to three reasons: (1) Alkali refining of bran oil causes much higher loss of oil than in other oils due to reasons not fully understood. (2) Rice oil, unlike other oils contains wax, removal of which is a little complicated. (3) Heat treatment, including improper parboiling and improper heat stabilization, and especially in presence of high FFA, causes darkening and fixation of colour in the oil, which is difficult to remove by bleaching.

For use in Vanaspathi, the pooled low-FFA bran oil is first deacidified, bleached and deodorized; the wax is not removed, for it gets diluted by being mixed with other oils. But it should be noted that even for refining, the FFA in the oil should not be too high, otherwise the refining losses become excessive. Moreover, oil with too high FFA cannot generally be made edible even by refining, because the proportion of glycerides in the oil may have changed unfavourably.

Refining of crude rice bran oil involves the following steps:

dewaxing	-	to remove wax,
degumming	-	to remove phosphatides,
neutralization or deacidification	-	to remove FFA (free fatty acids),
bleaching	-	to remove colour,
deodorization	-	to remove smell,
winterization	-	remove saturated glycerides

Dewaxing

Rice bran oil is unique in possessing a fairly high amount of wax. The wax causes much difficulty in subsequent refining and therefore must be removed before other steps of refining are attempted. The wax is soluble in oil-hexane miscella at usual extraction temperatures (60-70 °C) but is virtually insoluble at low temperatures. A double extraction system is therefore one approach to dewaxing, although this is expensive. The bran is first extracted with hexane at a low temperature (4-5 °C), when the wax remains insoluble, giving a wax-free oil. The bran is then extracted a second time at 60 °C, which on cooling yields wax as a precipitate. Alternatively, the conventional hot-solvent extraction followed by cooling of the miscella or of the desolventized oil can separate wax by deposition. The separated wax can be collected by centrifugation or filtration or by slow settling. However, as the viscosity (thickness) of the oil increases on cooling, separation of wax from oil by cooling is time consuming and hence expensive in tropical countries. Dewaxing in miscella (mixed with hexane) is easier as the viscosity is thereby reduced. But the process involves additional cost. Recently it has been observed that separation from the oil can be more easily achieved by adding a solution of a surface-active agent which wets the wax particles and helps their merging and separation.

Degumming

Gums and mucilages in vegetable oils generally consists of phosphatides and glycolipids. They may also include sugar and protein complexes in colloidal form. Prior degumming of oil is important, for polar lipids have surface-active properties and form an emulsion with the soap-stock formed during deacidification. So the soap-stock does not easily separate and occludes a lot of oil, thus leading to high losses of oil during neutralization. Phosphatides, if recovered, are valuable by-products, like lecithin. In case of deacidification by distillation or during heating for other reasons, prior degumming is a must, for otherwise high discolouration occurs during heating which is very difficult to bleach. Degumming is normally carried out by adding small quantities of phosphoric or citric acids followed by filtration or settling. Alternatively steam can be passed into the oil upto a temperature of 80-100 °C, or the oil can be heated with addition of a little water, which separates gum by flocculation (mutual adhesion and floating).

Deacidification

Removal of FFA from rice bran oil generally causes much problem. Due to some unknown reasons, high losses of oil occur during its alkali neutralization. However, prior dewaxing and degumming followed by carefully controlled addition of caustic soda and controlled time and temperature of heating can reduce refining losses to a minimum. One reason of the high loss of neutral oil during alkali refining is the fluffy and thin nature of the soap-stock which is difficult to separate and which therefore occludes considerable amounts of oil. Effort to reduce refining losses is directed to harden the soap-stock so that it settles easily without including any oil. Addition of certain chemicals such as sodium silicate, sugars (molasses), ethanolamine and some alcohols and glycols seem to achieve this and reduces refining loss.

Miscella refining (mixed with hexane) is an effective method of reducing refining loss, for the soap-stock separates easily in this case. Refining in the miscella has the additional advantage of giving less coloured oil.

Soap is obtained as a by-product of alkali neutralization. As the oil is mostly unsaturated, the soap is soluble in cold water.

Miscella refining using binary solvents (hexane and alcohol) is also done. The soap dissolves in the alcohol layer. Refining loss is low, but the process is expensive. Soap is recovered from the alcohol layer as fatty acids.

Another method of deacidification is to remove FFA by steam distillation in which case the free fatty acids are obtained as valuable by-products. The oil is heated to 200-240 °C under a high vacuum of 3-4 millimeters of mercury and is subjected to steam stripping. The free fatty acids distil over and are collected as distillate. There is no refining loss. However; the process is somewhat expensive. Its another disadvantage is that the oil colour tends to get deepened and fixed, leading to bleaching difficulty.

It has been suggested that high-FFA oil can be converted to low-FFA oil by any of the physical refining systems (distillation, miscella refining), and the low-FFA oil can then be further refined by alkali treatment or used in Vanaspati.

Bleaching

Bleaching of rice bran oil is carried out by conventional use of bleaching earths and activated carbon. Most pigments can be readily absorbed by bleaching earth or destroyed by heat, but oxidation, particularly in the presence of traces of iron or copper, can lead to fixing of colour and resistance to bleaching. Heating in presence of gums can also lead to darkening and difficulties in bleaching.

Deodorisation

This is carried out by heating the oil to 200 °C - 250 °C under high vacuum with dry steam to remove all volatile materials giving smell.

Winterization

If the oil is to be stored at refrigerated temperatures, such as for salad oil, winterization is necessary. The purpose of this step is to remove saturated glycerides which cause cloudiness to the oil when stored in cold. Winterization is achieved by chilling the oil and allowing the saturated fats to settle out.

Use of Rice Bran Oil

The characteristics of rice bran oil are broadly similar to other vegetable oils. Its fatty acid composition is roughly as follows:

Oleic acid	-	40-50%
Linoleic acid	-	30-35%
Palmitic acid	-	15-20%
Others	-	5-10%

Table 13.4: Valuable materials present in or obtained from rice bran oil

Material	Amount (% in oil)	Use
Wax	2-6	In polish, food wraps, cosmetics, leather, etc.
Vitamin E	0.1	Medicinal, as antioxidant
Squalene	0.3 – 0.4	Medicinal
Oryzanol	1 - 2	Medicinal, as antioxidant
Fatty acids	Variable	Industrial
Soap	Variable	Industrial
Gums (Phosphatides)	1 - 3	Like Lecithin. Emulsifying, wetting, dispersing
B Vitamins	In bran	Medicinal
Phytin	In bran	Food Processing industry
Inositol	From phytin	Medicinal
Microchemicals	In bran	Industrial and medicinal

High FFA rice bran oil can only be used for industrial purposes, including for making soap. As the oil is soft (it contains predominantly unsaturated fatty acids, as shown in Table 13.4), it is often hardened by hydrogenation before being put to industrial use.

Refined rice bran oil is good cooking oil. If properly winterized, it can be used as salad oil. It has low linoleic acid and high tocopherol contents, thus rendering it more resistant to oxidation than many other vegetable oils. At the same time its high amounts of oleic and linoleic acids make it a rich source of essential fatty acids and highly nutritious. It has a good cholesterol-lowering effect. Rice bran oil with less than 8-10% FFA is routinely used in making Vanaspati in India.

Crude as well as refined rice bran oil have many other industrial uses in small quantities.

By-Products of Refining

Rice bran oil contains many important materials which are obtained during its refining (Fig. 13.4). The wax is of high melting point (75-80 °C) which is not found in other vegetable oils. It is very similar to carnauba wax and has many industrial and cosmetic uses. Vitamin E (tocopherols) and squalene have medicinal properties. Oryzanol is an ester of ferulic acid and triterpenoid alcohols and is reported to have valuable pharmaceutical properties.

The above and many other chemicals and pharmaceuticals, including B vitamins and phytin, can be prepared from rice bran or the oil.

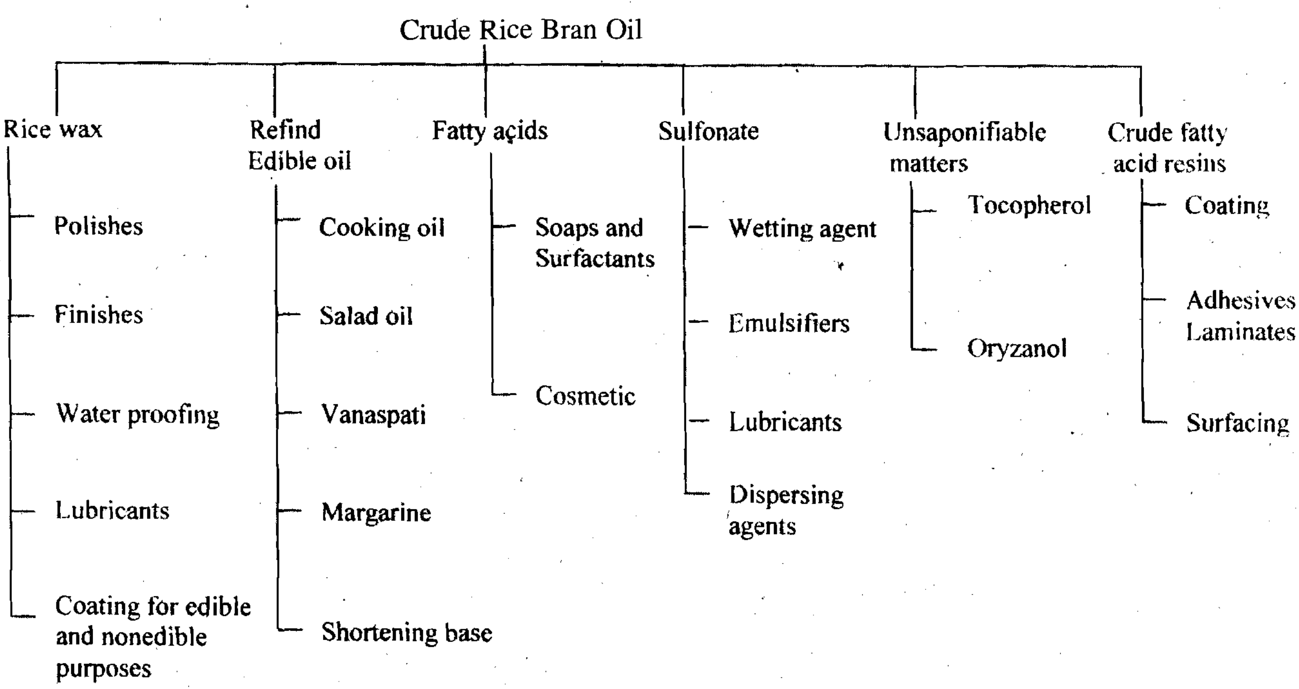


Fig. 13.4 : Potential uses of rice bran oil

Check Your Progress

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 rice bran and what does it contain?

....

....

....

2. What is the quantity of bran obtained from milling one quintal of paddy?

....

....

....

3. What affects the bran composition?

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4. What type of protein is contained in rice?

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....

....

5. What is the true density of rice bran and its angle of repose?

....

....

....

6. What are the different uses of rice bran?

....

....

....

7. What are different stages of refining of crude rice bran oil?

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....

....

13.6 LET US SUM UP

Rice bran is the most important by-product of rice milling (paddy processing) industry all over the world. The term bran is applied to the outer layers of the grain removed from brown rice during milling. It consists of pericarp and seed coat together with a major portion of the aluerone layer, part of the endosperm and the germ.

Rice bran contains about 15-20% oil by weight of bran which is extracted by pressing or solvent extraction process. This oil is called crude oil. This oil when subjected to the process of refining consisting of dewaxing, degumming, neutralization or deacidification, bleaching, deodorization and winterization yields oil fit for human consumption and is rich in micronutrients and B-group vitamins etc.

Defatted bran devoid of oil is an important source of animal and poultry feed. Efforts are in process to utilize it as human food.

13.7 KEY WORDS

Rice Bran	:	A hard outer layer of unpolished (brown) rice grain
By-product	:	A product obtained out of the main process (like bran in rice milling).
Degree of milling	:	It is the percentage weight of brown rice removed to get white rice
Rice husk	:	A outer layer covering the paddy grain which consists mostly of silica.
Albumin	:	A protein in rice bran which is soluble in water
Glutelin	:	A protein in rice bran which is not soluble in anything.
Bulk denisty	:	Weight per volume of material in bulk
Defatted rice bran	:	Rice bran from which most of the oil has been extracted
Phytin	:	Bran phosphrous existing in the form of Phytin
Chemical instability of Rice Bran	:	The process of fat hydrolysis in rice bran develops free fatty acids (FFA)
Solvent Extraction	:	Extraction of oil from oil bearing material by use of solvent such as Hexane or Alcohol
Pelletization	:	Process of forming pellets from rice bran
Dewaxing	:	Process of removal of wax from oil
Degumming	:	Process of removal of phosphatides from oil
Neutralization or Deacidification	:	Process of removal of FFA (free fatty acids) from oil
Bleaching	:	Process of removal of colour from oil
Deodorization	:	Process of removal of smell from oil
Winterization	:	Process of removal of saturated glycerides from oil

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13.9 ANSWERS TO CHECK YOUR PROGRESS

1. Rice bran is the hard outer layer of rice grain and consists of combined aleurone and pericarp. It is a by-product of milling process. It contains various antioxidants, oil, dietary fibre, starch, protein, vitamins and dietary minerals.

2. About 5 Kg of bran is obtained after milling one quintal of paddy.

3. Bran composition is affected by stage of polishing and number of polishers used during process.

4. Rice protein consists mostly of insoluble glutelin (about 80%) and small amount of albumin.

5. True denisty of rice bran is about 1.2 to 1.3 gm/cc and its angle of repose is 38 degrees.

6. Rice bran is used for extraction of protein, extraction of oil, hyman food and as animal and poultry feed.

7. Refining of crude rice bran oil involves the following steps:

   (i) dewaxing

   (ii) degumming

   (iii) neutralization or deacidification

   (iv) bleaching

   (v) deodorization

   (vi) winterization