POST HARVEST TECHNOLOGY
of
FOOD GRAINS

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Post harvest management and its importance

The stages through which the commodity passes from harvest till we consume that are considered as post harvest stages. Post harvest management is one important component of agriculture and is the key to make more food and nutrition available to people. This is very important when it is estimated that almost about 10% of the food grains and about 30-40% of the fruits and vegetables are lost every year in a country like India due to improper post harvest management and lack of value addition. We are all exploring new avenues to increase food production to meet the demand of growing population of our country. However, prevention of post harvest losses is also one basic step that can be taken up to make more food available for us. In addition, food processing also helps to increase employment and income, particularly in the rural areas.

Why post harvest management and food processing?

The proper post harvest management and food processing can help us in the following aspects.

1. Prevention of post harvest losses
2. Maintain the quality of food commodities till we consume that
3. Better use of surplus production
4. The food can be made available in offseason.
5. Value addition of the commodity
6. Gives additional employment and income

All these advantages are also associated with increase in the farm gate prices of the commodities. Further, when price is better assured, there is increase in crop area and diversification of crops, which are ultimately beneficial to the individuals as well as to the society.

The post harvest operations differ for individual commodities.

There is no general approach for post harvest management for agricultural commodities as they differ in their physical, chemical and textural characteristics. Their end forms and uses also differ.

The crops can be classified depending on the moisture content and storability as follows.


- **Durables.** The normal storage life (also known as shelf life) of the crops are few months to one or two years. The moisture content is in the range of 8-20%. The food grains as rice, wheat, corn, millets, pulses, oilseeds come under this category.

- **Semi-perishables.** The normal shelf lives of the crops are few weeks to few months. The examples of such commodities are potato, yam, onion, garlic, etc.

- **Perishables.** The normal shelf lives of the crops are few days only. The moisture content is more than 70%. Examples are most fruits and vegetables, meat, fish, milk, etc.

Accordingly, the post harvest management will also differ for the different groups. For instance, the food grains have as such a shelf life of several months and slight delay in the post harvest operations may not cause considerable damage to the commodity. But such delay is not permissible for fruits and vegetables. Even there are some fruits which can be stored for 7-10 days in room conditions, whereas some spoil even in a day or two.

**What are the spoilage agents and from whom we have to protect the food?**

All of us know that the major agents causing the spoilage of food in post harvest stages are the microorganisms, insects, rodents, birds, etc. who consume the food or infect the food to a level that it becomes inedible. However, the birds, insects and even the microorganisms can attack and spoil the grain only if the environment surrounding the food is conducive to them. A good example is that the grains can be stored for longer period if we store them in dry condition. The temperature of storage is also important and we know that the shelf life (storage life) of fruits and vegetables can be increased in refrigerators. Thus, there are a number of factors that affect the food commodity in storage and once we know the potential enemies, we can devise our own ways to protect the food.

Therefore, let us list the different factors affecting the spoilage/ loss of food commodity as follows.

1. Physical factors, e.g. temperature and relative humidity of storage environment, oxygen availability, etc.

2. Chemical and biochemical factors, e.g. the respiration of the commodity (the fresh fruits and vegetables are living bodies and they respire and the rate of respiration directly affects their storage life), other biochemical reactions occurring in the food.
3. Biological factors (microorganisms, birds, rodents, insects, etc.)

4. Engineering / mechanical parameters (design of storage structure, type of packaging, conveying and transportation devices, etc.)

The major losses to the grains are due to birds, rodents and insects. They consume the stored produce and damage the crops by infestation (insect infestation) and by their excreta. The fruits and vegetables are mostly spoiled by microorganisms and by drying and shriveling. Thus, considering the nature of commodity and the type of end use, we may plan for the post harvest management of agricultural produce.

**Basic post harvest operations**

The basic post harvest operations are aimed at three broad aspects.

1. Conversion of raw materials to edible form
2. Processing and value addition
3. Storage and preservation

**Primary, secondary and tertiary processing**

The processing operations can also be broadly classified as primary, secondary and tertiary processing. When we process agricultural commodities to improve its quality without changing the form such as operations like cleaning, grading and drying, it is known as primary processing. Primary processing can also include the operations to convert the inedible raw material to edible form like conversion of paddy to rice, or wheat to flour, etc.. However, to add value to the final product we go for secondary processing. The conversions of rice to rice flour and puffed rice, dhal to besan, etc. are secondary processing operations. Similarly preparation of extruded products from rice flour and dhal powder, corn flour, etc. are examples of tertiary processing.

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*Dean, CAET*
Primary processing of grains

In general, grain milling is the size reduction and separation process to convert the raw commodity to edible form. Some unit operations, which are common for all types of grains are **cleaning, sorting and grading, drying and conditioning**.

**Cleaning**

The basic objective of cleaning is to separate the unwanted materials like straw, chaff, stones, etc. from the grains. In addition to improving the grade of the commodity, it helps to protect the milling machines and save in storage space. Further, **the extraneous materials present in grain are always at higher moisture content than the average moisture content of the grain and help growth of insects and microorganisms**. So when we remove these extraneous materials, we also help to improve the shelf life of the grain.

The major equipment used for cleaning are the screens, where we separate the extraneous materials from the grain on the basis of size. Many types of grain cleaners are available commercially, in which the screens can be changed to meet the varied needs of different grains. Some important points to be remembered in respect to cleaning are as follows.

- Two screens can be assembled one above the other to separate the large size impurities (on upper screen), clean grain (on the lower screen) and the small impurities below the lower screen.
- The screens can be operated by electricity or diesel operated motors. Small size screen assemblies can be suspended by hangers and can be operated by hand.
- In commercial cleaners, an air blower (or aspirator) is also fitted with the screens to blow away the lighter materials like chaff, straw, etc.
- In some large grain processing units, some advanced types of grain cleaners/ graders are used such as the magnetic separators (which can separate iron nails, nuts, bolts and other magnetic materials, etc.) and specific gravity separators or destoners (to separate stones of same size as the grains, which are not separated by screens).
Drying

We all know that the dried grains store better than wet grains. It is because the microorganisms can not easily attack the dried grains. Depending on the type of grain, there is a safe moisture level for storage and the harvesting moisture content is much higher than that. For example, the paddy grain is harvested at a moisture content of 20-24% and its safe storage moisture content is about 12-13.5%. The safe storage moisture content of some food grains are given in Table 1. The safe storage moisture contents for the grains to be used as seeds is about 1-2% lower than the values given in the Table. So the grain should be dried as quickly as possible to reduce losses.

### Safe storage moisture content of some food grains

<table>
<thead>
<tr>
<th>Commodity</th>
<th>Optimum moisture content recommended for harvest</th>
<th>Storage moisture content for up to one year</th>
<th>more than one year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy</td>
<td>20-24</td>
<td>13.5</td>
<td>12</td>
</tr>
<tr>
<td>Wheat</td>
<td>16-18</td>
<td>13.5</td>
<td>12</td>
</tr>
<tr>
<td>Maize</td>
<td>20-23</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Sorghum</td>
<td>20-22</td>
<td>12</td>
<td>10</td>
</tr>
<tr>
<td>Pigeonpea</td>
<td>-</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Bengalgram</td>
<td>-</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Soybean</td>
<td>20-30</td>
<td>10</td>
<td>8</td>
</tr>
<tr>
<td>Mustard</td>
<td>-</td>
<td>8</td>
<td>6</td>
</tr>
<tr>
<td>Groundnut, unshelled</td>
<td>40-60</td>
<td>12</td>
<td>-</td>
</tr>
<tr>
<td>Groundnut, shelled</td>
<td>10-12</td>
<td>8</td>
<td>7</td>
</tr>
</tbody>
</table>

**Methods for drying**

The drying methods for the grain can be broadly classified as natural or field drying, sun drying, and mechanical drying.
When the grain is kept in the field/drying yard for some days after harvest it looses some moisture, and it is known as natural drying. The drying process is very slow.

The drying rate is improved if we dry grain under sun in thin layers (say 1-2 inches thick layers) and the process is sun drying. The sun drying is advantageous in that no extra energy is required for drying and there is no drying cost. But it is dependent on weather conditions and there are losses due to birds, rodents, etc. But if the grain is not properly stirred (mixed) during drying, there is uneven drying and cracks form in the grains. This is important when we require whole grains for our consumption such as rice. We cannot see the cracks in the naked eye, but during milling they cause breakage of the grain. Please note that most of the times the higher breakage in the rice mills may not be due to the problems in the mill or defective operation, but due to faulty or uneven drying.

There is one simple way by which we can control the drying process to reduce the breakage of rice grains during milling. Normally the cracks within the grain develop when the moisture content reduces through 16-18% level when it is being dried continuously. At that time the inner part of the grain is wet and outer layers are dry, which causes the moisture differential in the grain kernel and causes breakage. So, if we give a rest period for about 3-5 hours for the grain by heaping them, it equalizes the moisture variation within the grain and formation of cracks is substantially reduced. The drying is carried out in two stages and the resting stage is known as tempering. Tempering of the grain in between drying passes reduces breakage during milling.

Mechanical dryers

The different types of commercial dryers which are used for the grains can be classified as follows.

**Batch dryers:** Box type dryer, Bin dryer, Recirculatory batch dryer, Column batch dryer

**Continuous dryers:** Continuous flow bin dryer, Non-mixing type columnar dryer, Mixing type columnar dryer, LSU dryer, Fluidised bed dryer

**Batch dryer vs-continuous dryer**

1. The batch type dryers have less capacity and can be used for different types of grains. The continuous dryers usually have
high capacities and they are standardized for a particular grain.

2. Continuous dryers are seen in large rice mills as they are economical in labour and running cost.

3. The initial investment for batch dryers is less and suitable for small grain processing units.

**Mechanical drying is better than natural / sun drying.**

- Mechanical drying is faster than sun drying as higher temperatures can be maintained.
- It is possible to dry grains even during bad weather and rainy season.
- We can dry more amount of grain in short period.
- The drying can be controlled as per our needs.
- Development of cracks within the grains can be minimized.
- Losses due to rodents, pests and by shattering are avoided.
- The grain is not contaminated during drying.

Hence if the facility is available or affordable, mechanical drying should be preferred to sun drying. LSU dryers (expanded as Louisiana State University dryer) are semi-continuous mixing type dryers which are mostly used in commercial rice mills of India for drying of paddy. It basically consists of a long tower like drying chamber. The grain is lifted to the top of the tower and then allowed to fall very slowly along the tower by some specially arranged channels and with a suitable discharge device at the bottom. Hot air is passed through the tower during this time so that the grain dries while falling along the tower. The air is normally heated electrically or by husk fired furnaces fitted with the dryer. The grain remains for about 30-60 minutes in the dryer for a single pass (i.e. it takes 30-60 minutes to come from the top to bottom, which depends on the height of the tower and the speed of discharge from the bottom). If the grain is not dried in a single pass, then it is given a rest for about 3-4 hours and again fed from the top of the dryer. The dryer has a huge capacity and its performance as regards to uniformity in grain drying is very good.
Agricultural waste fired dryers can also be used for drying grains like paddy, dal etc. which can substantially reduce the drying cost. An agricultural waste fired furnace developed by OUAT has been successfully used for drying pulses during pre-treatment prior to milling. The dryer could dry 5 q of dal per batch in 2 h with fuel consumption of 40 kg fire wood. The cost of drying is about Rs 50/- per quintal of grain.

**Fig. 1 LSU dryer**

**Fig. 2 Agricultural Waste Fired Dryer**

**Solar dryers**

Solar dryers of different capacities are also available for the grains, which do not depend on electricity. They give a better quality product than open sun drying and can be of benefit during bad weather.

**Determination of moisture content**

We have been discussing that the determination of moisture content of the grain during harvesting and storage are very important. Similarly there is an optimum moisture content to get the best output
from the milling machines also. Thus, it is essential to know the moisture content of grains during storage and before milling. Though our people test the moisture content of grains by biting in teeth or by pressing in nails, many types of equipment are also available for the purpose.

A small equipment known as the universal moisture meter can help determine the moisture content of grains in just 1 minute. The equipment costs about ₹6000-10000, and can be used for small commercial establishments or storage godowns.

![Universal moisture meter](image)

**Fig. 3 Universal moisture meter**

Before determination of moisture content or for any protective measures, proper sampling of the grain is also important. Different types of samplers and seed dividers are available. Hand scoops, Nobbe trier, double sleeve trier (also known as grain probe) are simple devices to take samples from the gunny bags. We must remember that the grain is to be drawn from the centre of the container or stack/bag. The bag on the outer layers of the stack or the layer of grain close to outside environment may show less moisture content as it is continuously exposed to the outside free flowing wind.

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Rice milling technology

The milling of grains differs with the type of grain. The basic objective of rice milling is separation of outer husk and bran layers to get the maximum yield of unbroken rice grains. Thus, the two basic operations involved in rice milling are removing the outer cover (known as husk or hull) and the seed coat (called the bran). The former is called dehusking or dehulling, while the latter is known as polishing or whitening. Earlier, we were milling rice by manual hand pounders, chakkis or leg pounders, and now most of the rice is milled in hullers and modern rice mills.

Huller

The hullers are popular rice milling machines and are very well suited for small amounts of paddy.

However, the hullers have two major disadvantages, as follows.

1. As a huge pressure is applied on the grain for taking out the husk and bran layers in a single operation, there is a lot of breakage of rice. The breakage becomes very high for raw rice and for long varieties of rice.

2. In the huller, the husk and bran come out of a single outlet as a mixed powder form, which is used (and can be used only) as cattle feed. But the husk and bran, if obtained separately, can have many beneficial uses. In particular, the rice bran is a good source of oil (100 kg rice bran can give about 20-25 kg oil) and the oil can be used for cooking and other purposes. The husk is a very good fuel and is commonly used as the fuel for the parboiling and drying operations in rice mills. It has also many agricultural and industrial uses.

Modernised huller

As we discussed above, hullers are not good machines so far as the quality of rice and by-products are considered. But modern rice milling machines require huge investment and it is not possible for small millers to immediately discard the hullers and go for modern rice mills. Therefore, a solution as a compromise between the huller and modern rice mill has been suggested for huller owners, which is known as “modernisation of huller”.

( Page 10 )
In the modernised huller, a **paddy cleaner, rubber roll sheller and husk aspirator are fitted above the existing huller to clean, dehusk and separate the husk from brown rice. Then the existing huller is used as polisher.** After polishing, we may add graders to separate the brokens from the whole rice (the whole rice is also known as head rice).

![Fig. 4 A huller](image1.png) ![Fig. 5 A modernised huller](image2.png)

**Modern rice mill**

In the modern rice mill, the dehusking and bran removal are carried out in two stages so that the husk and bran are obtained separately. The equipment used are known as **sheller (rubber roll sheller) and polisher,** respectively. In addition, to improve the performance of the rubber roll sheller and polisher and also to get good quality rice and bran, some other machines as cleaners, husk aspirators, etc. are also fitted in a modern rice mill. The flow process in a modern rice mill is shown in Fig. 2. Table 1 gives an idea of the type of machines and their cost used in a modern rice mill.

Sophisticated rice mills used for processing long grain basmati rice includes vibro cleaner, pneumatic sheller, whitener, silk polisher and colour sorter for reduction of breakage during milling and production of super quality rice.
Table 1. Approximate cost of a mini rice plant (capacity 900 kg rice per hour).

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Description</th>
<th>Power</th>
<th>Rate</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>One Rubber Roll Paddy Dehusker Model Super-2 DL-6”(with (\text{4 hp}))</td>
<td>(\text{4 hp})</td>
<td>(\text{30000/-})</td>
</tr>
<tr>
<td>Item</td>
<td>Description</td>
<td>Power</td>
<td>Price</td>
</tr>
<tr>
<td>------</td>
<td>-------------</td>
<td>-------</td>
<td>-------</td>
</tr>
<tr>
<td>2.</td>
<td>Two Cone Polisher 24&quot; (With Emery) With cutter</td>
<td>10 hp x 2pcs</td>
<td>190000/-</td>
</tr>
<tr>
<td>3.</td>
<td>One Paddy Separator tray type</td>
<td>2hp</td>
<td>85000/-</td>
</tr>
<tr>
<td>4.</td>
<td>One Mini Paddy Cleaner</td>
<td>2hp</td>
<td>30000/-</td>
</tr>
<tr>
<td>5.</td>
<td>One Mini Rice Cleaner Cum Grader</td>
<td>2hp</td>
<td>30000/-</td>
</tr>
<tr>
<td>6.</td>
<td>Five Elevator 14&quot;/1pc &amp; 12&quot;/6pcs Complete with buckets</td>
<td>3hp</td>
<td>150000/-</td>
</tr>
<tr>
<td></td>
<td>Area Required for Machinery 25'[l] x 10'[w] x 16'[h]</td>
<td>Total</td>
<td>530000/-</td>
</tr>
</tbody>
</table>

(Note:- Above plant can be run on 20 hp diesel engine through line shaft; machinery are quoted without electricals and line shaft arrangement.)

The modern rice mill gives higher output of rice. But the husk and bran are obtained separately, which can not be used as cattle feed. So the people who wish to take back the by-products for feeding their cattle along with the rice, do not opt for modern rice mills. Besides, proper facility for use of husk and bran are also not available in all areas. These are some reasons why the hullers are still popular in the rural areas for custom milling. However, considering the extra yield of rice and potential beneficial uses of by-products, the modern rice mills can give higher income to compensate the loss caused by losing the cattle feed. Anyway for commercial milling, the modern rice mills have no substitute.

It is not only the milling machine, but also the pre and post-harvest operations affect the output from rice milling. A modern rice mill alone cannot give the best recovery of rice. In fact, the series of pre- and post-harvest operations also significantly affect the output of rice from a mill. The five finger rules (related to post harvest activities) for getting the best output from rice milling can be as shown in Fig. 5.
Conditioning/parboiling of rice

Parboiling is a hydrothermal treatment that improves the hardness of rice and nutritional quality. As the hardness is increased, the breakage during milling is reduced. Parboiled rice also stores better as it is less attacked by the insects due to increased hardness. The nutritional quality is also improved because during conditioning, the steam and water try to carry most of vitamins and minerals from outer layers to inner part of the grain and distribute them there. Subsequently the loss of these nutrients is less during milling and cooking. Of course, many people do not like parboiled rice due to the slight change in colour and as it takes more time to cook.

There are 3 basic steps in parboiling, namely, soaking, steaming and drying. The steaming should be uniform and for that good designs of steaming tanks are available. The CFTRI (Central Food Technological Research Institute, Mysore, India) design is a good example of a steaming tank, where the treatment is almost uniform and the quality of rice is acceptable.

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Rice products

Preparation of rice products as flaked rice, puffed rice, popped rice, rice powder, rice cakes, extruded products, etc. are common activities in rural areas. These types of products can be called secondary rice products. About 5-10 per cent of the total production of paddy in India is used for production of these. These products are mostly prepared on small and medium scales, even though very large capacity flaked rice plants are also available. In many places, these activities are carried out along with the general rice milling activity. However, due to the traditional methods and equipment, it is often observed that the yield and quality of these products are not satisfactory and the products do not command a good price in the market. Therefore, we will discuss about the methods of preparation of some important secondary rice products and by-products.

Rice flakes

The rice flakes (flaked rice) or parched rice is prepared by pressing the grain. During pressing, the rice kernel should be somewhat soft so that flakes are formed rather than powders. Hence the grain has to be conditioned first to make it soft. **Thus, the method of preparation of rice flakes can be broadly divided into two parts, viz. the conditioning of the grain and then the pressing.**

![Diagram of Rice Flaking Process]

**Fig. 9 Rice flaking process**
**Conditioning.** The steps of conditioning and milling are shown in the Figure. For the traditional method of conditioning, there is a need of continuous stirring of soaked paddy during roasting, which is a tedious operation. Hence, for preparing flakes on a commercial scale, a roaster is used instead of the furnace and the frying pan. Different types of roasters are available, which use either electricity or other fuels like diesel, firewood, coal, etc. for heating purpose. Some use sand and some do not need any support material for heating. High capacity continuous roasters are also available.

**Flaking.** The conditioned paddy is pressed either manually or by a machine called edge runner. There is another type of machine called roller flaker, in which conditioned rice grain is pressed rather than paddy. The conditioned paddy is first milled to rice form and rice is fed to the roller flaker.

**Puffed rice**

If properly conditioned rice is roasted at a very high temperature, it causes puffing of rice. The rice that is used for the purpose should have good puffing characteristics. Here also, two basic steps are associated with preparation of puffed rice, namely, conditioning and puffing.

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**Fig. 10** Conditioning and roasting for preparation of puffed rice

<table>
<thead>
<tr>
<th><strong>Conditioning</strong></th>
<th><strong>Roasting</strong></th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Soaking paddy overnight in warm water</td>
<td></td>
</tr>
<tr>
<td>2. Draining of excess water in the next morning and mildly heating on sand. The paddy should be continuously stirred during the heating process for uniform heating.</td>
<td></td>
</tr>
<tr>
<td>3. Drying of paddy</td>
<td></td>
</tr>
<tr>
<td>4. Milling in a huller to prepare rice</td>
<td></td>
</tr>
<tr>
<td>5. Heating rice gently over a furnace for a short time. After the temperature of the grain has increased a little bit and some moisture has evaporated, a small amount of salt solution is added to rice and mixed thoroughly.</td>
<td></td>
</tr>
<tr>
<td>6. Heaping (tempering) the grain for some time.</td>
<td></td>
</tr>
</tbody>
</table>
Fig. 11 Jacketed Roaster Batch type

Fig. 12 Vertical batch roaster (no sand)

Fig. 13 Edge runner
As mentioned in Fig. 14, about 30-40 ml of salt solution is mixed with one kg rice. The moisture content of the rice after mixing the salt solution should be within 10.5 to 11 per cent. After the conditioning process, the actual roasting/ puffing is done in hot sand for a few seconds. The sand temperature is about 250°C. During this roasting, the rice is stirred vigorously. The quantity of sand used for roasting should be approximately 10 times that of the rice. The roasting should be done for about 10-11 seconds.

The conditioning of paddy can also be done by the pressure parboiling method. In this method, paddy is at first washed thoroughly with water at room temperature. Then, the drained paddy is subjected to high pressure steaming in a tank at steam pressure of 2-2.5 kg/cm² (Fig. ____). After 15 minutes of steaming, the paddy is taken out and dried in a mechanical dryer or spread under sun. The dried paddy is milled and rice is prepared.

Then the rice is mixed with salt solution as we do in the traditional method. It has been found out that high pressure parboiling gives better puffing characteristics than that by dry heating method.

**Fig. 14 Flow chart of Pressure parboiling method**

Puffing can be carried out in any of the roasters as mentioned earlier. Specially designed rice puffing roasters with capacities ranging from 20-1500 kg/ hour are also available. In addition to controlling the
parameters in the conditioning and roasting process, it is also very important to select suitable variety of rice with good expansion characteristics for producing puffed rice.

**Rice cakes**

Rice cakes are very popular in countries like Japan, Korea and China as a low calorie, low fat snack food for many decades. Rice cakes have only two critical ingredients—rice and water. The rice cake preparation process is based on the fact that when rice is subjected to the proper combination of heat and pressure, it will expand to fill a given space. Sticky rice, whether white or brown, tends to work best, while long-grain varieties do not expand during cooking as vigorously. Other ingredients like salt (added before popping or sprayed on after) and various flavourings are important considerations to taste-and nutrition-conscious consumers but are not significant for the production process.

The preparation method is as follows.

1. First the suitable variety of raw rice is selected (depending on stickiness, expansion potential, and taste) and soaked in water until the desired level of moisture is attained.

2. The moist rice is fed into hoppers above popping machines from where it goes into the cast-iron mold or cooking head in the popping machine. The mold is heated to hundreds of degrees, and a slide plate opens to impose a vacuum on the moist rice mass. After 8 to 10 seconds of exposure to heat at this pressure, the lid of the mold expands, creating an even greater vacuum on the contents. In the last few seconds of heating, the mixture explodes to fill the given space. If the rice expands more, its texture will be better. The bran and other components of the rice bond to each other so that popped mixture sticks together without gumming additives.

3. After the cake has exploded in the popping machine, the cooking head opens and the cake falls gently on a conveyor belt.

4. The belt carries the cake past one or more spraying heads where salt may be added or the cakes are flavour-enhanced.

5. Then the conveyor passes through a tunnel dryer where the moisture added by the flavour sprays is evaporated.

6. The conveyor moves to the bagging area, where the rice cakes are removed from the conveyor by hand, inspected for any breakage, and stacked, sealed in shrink-wrap, and packaged.
in an overwrap bag printed with the product identification and sealed. The bags are then packed in cartons for bulk sale.

**Vermicelli**

Rice vermicelli are thin noodles made from rice, sometimes also known as rice noodles or rice sticks. The rice paste is steamed and made into different texture and shapes via different processes. All types or varieties of rice do not give a good quality product. Rice with high amylose content gives better noodles. In some countries like the Philippines, corn starch is added to the rice for the production of noodle.

![Fig. 15 Rice vermicelli](image)

The process for making rice noodles differs from that of the wheat-based noodles. Primarily, extrusion of the wet dough rather than sheeting is used during processing. The extruded noodles are then fully cooked by steaming for about 60 to 120 minutes. After cooking, they are allowed to cool down at room temperature. During this process of slow cooling, retrogradation of starch occurs which will lead to a noodle with very low cooking losses. After cooling, the noodles are rinsed with water and then folded and portioned. The portioned noodles are then dried to about 11 per cent moisture.

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Beneficial uses of rice milling by-products

The rice husk and bran are very valuable by-products of a modern rice mill. If these products are not channelised into the production of value added products, then the total investment for a modern rice mill may not be justified. A rice mill processing forty tonnes of paddy per day also produces about eight tonnes of rice husk and 2 tonnes of rice bran per day. Thus, proper utilisation of rice husk can add to the overall earnings of the rice mill. Besides, proper use of this valuable resources is a social responsibility also. In this section, we will discuss about the beneficial uses of rice bran and husk.

Uses of rice bran

The outer brown layers of unpolished or brown rice contain considerable amount of protein, fat, vitamins, minerals etc. For better digestibility and proper utilisation of nutrition of rice, these layers need to be removed. Besides, the removal of these layers imparts better cooking quality to rice. Hence, these layers are detached by a polisher either by rubbing the brown rice against an abrasive surface or by rubbing grains with themselves.

The amount of bran (surface layers) removed from the grain, when expressed as per cent is known as the degree of milling or degree of polishing. For example if 6 kg bran is removed from 100 kg brown rice, the degree of milling is 6 per cent and if 8 kg bran is removed from 100 kg brown rice, then the degree of milling is 8 per cent.

As because the concentrations of proteins, oil, vitamins and minerals are more in the outer layers of brown rice, with the increase in the degree of milling of rice, the protein, oil, vitamins and mineral contents of rice are decreased and the carbohydrate percentage is increased.

The major use of rice bran is in the form of oil. The bran obtained from raw and parboiled rice contains about 12-18 per cent and 18-28 per cent oil, respectively. Therefore, rice bran has been recognized as a major source of oil. The rice bran oil (RBO) is used both for edible and inedible purposes.

Rice bran oil is easy to digest and hence is gradually becoming popular. Properly processed rice bran oil has less viscosity and foods
cooked with this oil absorb less oil. It helps in reducing calories, better, lighter tasting food and enhanced flavour and palatability.

The advantages of rice bran oil as compared to other types of oil can be broadly summarised as follows.

- RBO has more nutritional value with essential ingredients and more micronutrients.
- Its taste and flavour are comparable to the taste and flavour of most acceptable oils available in the market.
- Protects the heart and related blood vessels in a better way.
- Offers a longer shelf life.
-Comparatively more stable at higher temperature.

**FFA in rice bran.** The quality of bran oil is mostly decided by its free fatty acid (FFA) content. We have to remember the following points in connection with the use of rice bran as oil.

- The FFA content in the rice bran just after milling is very less and may be less than 1 per cent.
- But the FFA content of bran increases during storage by the activity of an enzyme called lipase.
- This process is very rapid under favourable conditions and FFA content can increase by up to 20 per cent per day and 70 per cent per month.
- But an oil having more than 3 per cent FFA is harmful to health. The high FFA oil has to be treated or refined to reduce the FFA to a level less than 1 per cent.
- But it is not economical to refine oils having more than 8 per cent FFA and hence, high FFA oil is used only for industrial purposes.

- **The increase in FFA content of bran depends on many factors as the mill environment, storage time, temperature, relative humidity of the storage space, etc.**

- Even if the bran obtained from a rice mill has low FFA content, if not properly stored or transported, the FFA content may rise making it unsuitable for edible use.

- There are methods and equipment to help stabilise the FFA level within reasonable limits, which is known as ‘rice bran stabilisation’.

- The increase in FFA is more for raw rice bran even if the storage is under relatively low temperatures. But FFA content of parboiled rice bran does not increase easily. During
parboiling of paddy, most of the enzymes are inactivated by the application of heat.

- Some micro-organisms and insects also secrete lipase. Hence, in some instances, although the lipase of bran has been inactivated, FFA content of the bran could increase due to presence of these external organisms. Hence, in addition to stabilisation of bran, the bran should be kept free from insects and micro-organisms by application of smoke or appropriate insecticides. Plastic lined thick bags are suitable for storage of bran as it protects the product from both insects and humidity.
- The rice bran having high FFA level is not suitable for edible oil extraction. Hence, in order to prepare edible oil from rice bran, it is essential to prevent rise of FFA level during storage till the oil extraction. The best possible method can be to extract the oil as soon as the bran is separated from rice. **It is very important that the rice bran should be sent to the oil extraction plant as quickly as possible and the oil should be extracted within 3-4 hours of polishing.** The FFA content during this time remains below 3 per cent, and the crude oil can be of edible grade.
- But this is not possible in most of the places as rice bran oil extraction plants are not in the vicinity of rice mills and the time lag between production of rice bran and processing into oil form is often very high.

**Other uses of rice bran**

Rice bran can also be used for preparation of protein rich food and feed, different medicines and chemicals, plant nutrients, etc. The different industrial uses of rice bran includes preparation of soap, protective coatings, wax, fatty acid, gum, etc.

**Stabilisation of rice bran**

Stabilisation is a process by which the enzyme lipase responsible for increase in FFA in rice bran is inactivated and thus further rise in FFA is restricted. The equipment used for this is known as bran stabiliser. Rice bran stabilization is mostly done by any one of the three principles as follows.

1. Drying and storage in airtight containers
2. Heating (by steam, by dry air, or by heat exchangers
3. Addition of acid
Growth of rice bran oil production in India as compared to actual potential

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Paddy production, million MT</td>
<td>119.40</td>
<td>127.50</td>
<td>129.60</td>
<td>133.78</td>
</tr>
<tr>
<td>Rice bran oil potential, lakh MT (15% Recovery)</td>
<td>9.00</td>
<td>9.57</td>
<td>9.72</td>
<td>10.02</td>
</tr>
<tr>
<td>RBO production</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>edible : Lakh MT</td>
<td>3.10</td>
<td>3.80</td>
<td>6.00</td>
<td>7.80</td>
</tr>
<tr>
<td>non-Edible : Lakh MT</td>
<td>1.70</td>
<td>1.20</td>
<td>0.50</td>
<td>0.20</td>
</tr>
<tr>
<td>Total : lakh MT</td>
<td>4.80</td>
<td>5.00</td>
<td>6.50</td>
<td>8.00</td>
</tr>
<tr>
<td>Untapped potential rice bran oil, lakh MT</td>
<td>4.20</td>
<td>4.80</td>
<td>3.22</td>
<td>2.02</td>
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<tr>
<td>Percentage of exploitation</td>
<td>53%</td>
<td>50%</td>
<td>67%</td>
<td>80%</td>
</tr>
</tbody>
</table>

Source: Solvent Extractors Association of India, Economic Survey 2010-2011

**Extraction of rice bran oil.** The rice bran oil is mostly extracted by solvent extraction. Hexane is the most commonly used solvent for rice bran oil extraction. It has a boiling point of 66°C. The process is shown in Fig. 13.

**Refining of bran oil.** The oil extracted by a mechanical expeller usually contains very limited impurities after proper filtration and can be directly used for edible purpose. But during solvent extraction, some other ingredients of rice bran as wax, colour compounds, etc. are also extracted along with the bran oil. These are considered as impurities of the oil. It is essential to separate these impurities to make the oil look attractive and be fit for edible purposes. The process is known as refining. The different stages of rice bran oil refining are shown in Fig. 14.
Uses of husk
Because a huge amount of the rice husk is produced along with the huge rice production, it can serve as an important raw material for preparation of different products. In fact, more and more uses of husk are being developed with continuous research. Some of the current uses/ possibilities of use of rice husk are as follows.

1. As fuel
   a. Fuel in rice mills and for cooking purpose
   b. Husk briquettes
2. Industrial uses
   a. as a mix in cement concrete
   b. Insulating material
   c. Refractory brick
   d. Ceramic/ Glass materials
e. Abrasive materials
f. Char
g. Panel board
h. Furfural
i. Solvent
j. Sodium silicate
k. Precipitated silica
l. Silicon tetrachloride
m. Molecular sieves
n. Activated carbon
o. Other chemicals

3. Uses in agricultural sector
   a. As constituents in the cattle- and poultry feed
   b. As a mulching material
   c. As a soil conditioner
   d. As insecticides for crop protection
   e. For preparation of beds in animal and poultry rearing
   f. For the preparation of compost

In fact, husk is effectively used in most of the advanced countries, but the valuable utilisation is yet to be popular in developing countries like India. Even though husk can be used immediately as fuel and for preparation of poultry feeds, but its low bulk density, low burning ability and high amount of residual ash (about 25 per cent) are the major factors for the low utilisation of rice husk ash.

Anyway, considering the ingredients of the rice husk, its potential of utilisation and the huge amount of husk produced in the modern rice mills, it can be said that rice husk has enough promise to be one of the most important by-product of the food processing industry.

Thus, we have understood that the effective utilization of rice milling by-products can not only be beneficial to the farmer, but also can be helpful in reduce the pressure on fuel and on oil. However, it is also important that proper methods of processing and storage are equally important for proper utilization of these by-products.

*Dr. Sanjaya Kumar Dash*

*Professor*
Processing and value addition of maize

Maize is considered a promising option for diversifying agriculture in upland areas of India. It now ranks as the third most important food grain crop in India. The maize area has slowly expanded over the past few years to about 6.2 million ha (3.4% of the gross cropped area). This area would grow further to meet future food, feed, and other demands, especially in view of the booming livestock and poultry producing sectors in the country. Increasing production and productivity also brings a lot of challenge in handling and processing.

Post harvest operations of maize

To minimise post harvest losses, the following steps should be followed.

- Harvest the kernels with 25 to 30 percent moisture.
- Use proper method of harvesting and dry the cobs immediately before threshing/shelling.
- Use a maize sheller to shell the kernels from the cob to avoid physical damage to kernels in traditional beating method with stick in a sack which makes it more vulnerable to pests and mould in.
- Dry kernels should be dried sufficiently before storage up to safe moisture content of 12%.
- Losses in threshing and winnowing should be avoided by using proper machineries.
- Use proper techniques for cleaning to remove foreign material such as husk, straw, dust, sand and material harmful to the milling equipment such as metal and stones.
- Adopt grading practices for proper evaluation and obtaining better price.
- Use proper maize grain storage system to avoid deterioration both in quantity and quality, and strong, and free from infestation packaging material for storage and transportation.
- Use proper scientific technique in storage for maintaining optimum moisture content.
- Use pest control measures (fumigation) before storage.
- Provide aeration to stored grain and stir grain bulk occasionally.
- Use proper techniques while handling (loading & unloading), good and fast transport to avoid losses during transport.
Grading of maize

The following quality factors are considered while grading.

- Moisture content
- Foreign matter
- Other food grains
- Admixture of other varieties
- Damaged grains
- Immature grains
- Weevilled and shrivelled

Important safety parameters that should be kept in mind while handling maize:

- Residue of Pesticides
- Poisonous/Heavy metals
- Aflatoxin
- Uric acid
- Microbial load

Requirement for purchase by FCI

<table>
<thead>
<tr>
<th>S. No</th>
<th>Refractions</th>
<th>Maximum Limits (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Foreign matter*</td>
<td>1.0</td>
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<tr>
<td>2</td>
<td>Other food grains</td>
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<tr>
<td>3</td>
<td>Damaged grains</td>
<td>1.5</td>
</tr>
<tr>
<td>4</td>
<td>Slightly damaged, discoloured &amp; touched grains.</td>
<td>4.5</td>
</tr>
<tr>
<td>5</td>
<td>Shrivelled &amp; Immature grains.</td>
<td>3.0</td>
</tr>
<tr>
<td>6</td>
<td>Weevilled grains</td>
<td>1.0</td>
</tr>
<tr>
<td>7</td>
<td>Moisture content</td>
<td>14.0</td>
</tr>
</tbody>
</table>

Standards of Central Warehousing Corporation

Percentage of weevilled grains:

- Up to 1%: A
- Above 1% up to 4%: B
- Above 4% up to 7%: C
- Above 7% up to 15%: D

AGMARK standard

<table>
<thead>
<tr>
<th>Grade-1</th>
<th>Moisture</th>
<th>Foreign matter</th>
<th>Other edible grains</th>
<th>Admixture of different varieties</th>
<th>Damaged grains</th>
<th>Immature and Shrivelled grains</th>
<th>Weevilled grains (percent by Count)</th>
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<tr>
<td></td>
<td>12.00</td>
<td>0.10</td>
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<td>5.00</td>
<td>1.00</td>
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<td>Grade-</td>
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<td>0.1</td>
<td>1.00</td>
<td>10.00</td>
<td>2.00</td>
<td>4.0</td>
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<tr>
<td>-------</td>
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<td>-------</td>
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<td>-----</td>
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<tr>
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<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Grade-</td>
<td>14.00</td>
<td>0.50</td>
<td>0.25</td>
<td>2.00</td>
<td>15.00</td>
<td>3.00</td>
<td>6.0</td>
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<tr>
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</tr>
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<td>Grade-</td>
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<tr>
<td>IV</td>
<td></td>
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</tr>
</tbody>
</table>

**Dry Milling**

Milling of maize for transforming into food and industrial products is done by two methods i.e. dry milling and wet milling. Hammer milled maize meal obtained by dry milling method would generally represent an undefined class, probably closest associated with Special Sifted maize meal and represents the lowest cost option and suitable to many rural applications. This meal is often considered inferior by the trade, for the following reasons: All the bran, germ and endosperm are ground up and hammered through the aperture in the hammer mill screen. This has the result that the meal has a short shelf life (the germ becomes rancid very fast after milling). So germ and hull are removed from maize before milling for safe storage life.

**Conditioning**
- Conditioning and tempering (application of water.)
  It refers to the addition of moisture to the maize to 21% m.c for toughening and loosening of bran and germ to be peeled off in flakes during milling with plate or roller mills.
- Degermination (using degerminator)
- Sifting by a vibrating screen
- Drying to milling moisture content
- Milling (hammer mill, Roller mill, Attrition mill)

**Wet milling**

Wet milling is the industrial process for extracting starch from maize.

**Steps for wet milling of corn**
- Cleaning to remove foreign material and broken kernel
- Steeping to soften the corn kernels for grinding
- Coarse milling in water to detach the germ
- Separation of germ (using Hydroclone/Screen)
- Grinding (using burr mill/ stone mill/Attrition mill) to free the starch
- Separation of fibrous material (screening) derived from pericarp and endosperm cell walls
- Separation of starch (Centrifuging or settling/decanting) from protein
- Drying and grinding

**Fig. 18. Wet milling of corn**
Fig. 19 value added products from maize

Fig. 20 Maize degermer/dehuller  Fig. 21 Hammer mill
Steps for corn flake processing

The milling process removes the corn kernels from the cobs and turns them into flaking sized 'grits'. Malted barley can be added to enhance the flavor of the Corn Flakes. The corn grits are cooked in steam pressure cookers, at temperatures exceeding 100°C. This cooking process lasts for an hour and softens the hard grits. During cooking additional water is incorporated in the form of steam which condenses and the water content in the batch rises to 30-35%. The grits spend several hours in the hot-air driers in order to reduce their moisture content. The corn grits are milled using rollers, which squeeze the grits flat. The flakes are then tumble toasted in huge cylindrical ovens. The air in the ovens is heated by 600°C gas flames and the flakes are tossed around in a rotating drum. The drum is angled so that the flakes whirl around and pass through it quite quickly, and stops them spending too long in the fierce heat. The flakes are then coated with chocolate on demand and also sprayed with flavors, minerals to make them as nutritious as possible. The Corn flakes are then bagged up with the help of a bagging machine, which uses rolls of polythene.

- Degermination (Bran, husk removal)
- Grading
- Steam cooking of corn grits
- Tempering
- Flaking
- Drying
- Roasting
- Packaging

Maize based products

Different value added products such as Flour, Semolina, Grits, Corn starch, Glucose, Gluten meal, Popped corn, Corn flake, Extruded product, Bakery Product, Corn oil and Feed from maize can also be prepared by maize based enterprises.

*Dr. Manoj Kumar Panda*

*Assoc. Professor*


Processing of ragi for value addition

Finger millet (*Eleusine coracana*) commonly known as ragi is grown as an important food crop in many developing countries of the tropical region. India accounts for about 40 percent of the world’s millet output. In Odisha, ragi is one of the major grains with an annual acreage of 65 thousand hectares and production being 41 thousand tones (20% of national average). It has intense coloured seed coat and coarse texture which are contributing factors in negative acceptance. The main traditional use of ragi is conversion to flour for preparation of ragi *roti* and *kheer* which is not attractive and is less popular among urban people with modern life style.

The attributes for health benefits of ragi includes perfect health balance, relatively higher proportion of nonstarchy polysaccharides (dietary fibre), hypoglycaemic, hypocholesterolemic, excellent malting characteristics, enhance the bio availability of nutrients, protein quality equal to that of milk, higher proportion of unsaturated fatty acids in fat, high calcium and iron content.

Despite all the nutritional and therapeutical uses of the ragi, it has received acceptance only among the less privileged section of population in rural areas mainly because of its characteristics colour and traditional preparation. In order to enhance market demand for these crops, aspects of diversified utilization and development of value added products are to receive much greater attention.

**Why value addition ?**

- Ample scope for diversified uses of ragi at household level and value added products through appropriate processing technology
- Ragi flour can be substituted and utilizing in products like baked, roasted, steamed, fried, boiled, fermented products at a lower cost with higher nutritional value.
- High malting power and with a type of starch that is more resistant to hydrolysis, renders its use for producing a variety of nutritionally designed food from infants to old.
- Ragi proves to be very effective in controlling the blood glucose level and cholesterol level. Calcium deficiency leading to bone and teeth disorders and iron deficiency leading to anaemia can be surmounted by introducing ragi in our daily diet.
Relatively higher proportion of dietary fibre of ragi with low fat provide several nutritional and physiological benefits namely hypocholesterolemic and hypoglycaemic effects, brings down the incidence of colon cancer, constipation and gastrointestinal complications.

Source of income generation which will provide alternate employment to rural community especially during lean season.

**Ragi pearler for small millets and oil seeds**

The post harvest handling processes of ragi are threshing and pearling (removal of the upper thin and smooth coating called glumes of ragi millets). Threshing and pearling of ragi is difficult as the small sized grains are held quite firmly in the glumes and therefore require considerable pressure coupled with repetitive impact and shear. The present practice of threshing is to beat the panicles manually over a hard surface. Pearling of ragi is conventionally done by hand and foot pounding. The removal of grains is usually done by pearling followed by winnowing or sieving. Pounding gives a non-uniform product that has poor keeping qualities. This practice is inefficient, labour intensive, time consuming, tedious and unhygienic. Vivek thresher developed by VPKAS, Almora can be used for threshing and pearling of ragi. The threshing and pearling capacity of the machine is 36 and 44 kg/h, respectively.

The equipment consists of a hopper, pearling chamber, cylindrical drum with canvas strip mounted on the impeller surface, sieve replacement slot, glume outlet, blower, cleaner assembly, air control device, grain outlet and feed rate controlling device. Sieves of different sizes (2.0, 2.4 mm) have been provided to fit into the mounting during different operations. Keeping the size of ragi in view, the first sieve with 2.4 mm diameter holes and second sieve with 2.0 mm diameter are used for threshing and pearling respectively.

**Fig. 24 Pearling of ragi in Vivek thresher**
**Malting**

Malting is a process in which grains are made to germinate by soaking in water, and are then halted from germinating further by drying with hot air. Malted grains develop the enzymes required to modify the grain’s starches into sugars, including the monosaccharide glucose. It also develops other enzymes, such as proteases, which break down the proteins. Malted grain is used to make weaning food, instant mixes, pharmaceutical products, malted shakes, confections and flavored beverages and some baked goods. An added advantage of malting ragi is the production of an agreeable odour developed during the kilning of the germinated grain. Malted ragi flour is called ‘ragi malt’ and is used in the preparation of milk beverages. Compared to other millets, ragi is most suitable from the stand point of product quality and enzyme release for malting. The malted ragi flour can be used along with germinated green gram flour to formulate a high calorie dense weaning food having excellent digestibility, sensory and nutritional qualities. There are various benefits of malting such as vitamin-C is elaborated, phosphorus availability is increased and lysine and tryptophan are synthesized which are ultimately beneficial to growing children, teenagers, pregnant women, lactating women and anaemic patients.

**Preparation process of ragi malt**

Grains are cleaned and washed thoroughly to remove immature grains, light materials and dirt. Clean grain is steeped in surplus water at room temperature (28±2°C), overnight. After soaking, the grains are drained, spread on aluminum tray (7±1 mm bed thickness), covered with moistened muslin cloth and germinated for 48 h at 28±1°C and 93±2% relative humidity (RH). During germination, the millets are gently mixed in order to aerate and prevent from matting; sprayed with water and covered with wetted muslin clothe twice a day. The germinated millet (green malt) is dried in a mechanical dryer at 50±2°C for 10 to 15 h (final moisture content of 9±1%) and the rootlets are removed by rubbing and winnowing. This is either used directly or further milled in attrition or hammer mill to semolina or flour. These processing add value to these millets three to four-fold and make them acceptable to the elite urban consumers as niche food or health food. The malted ragi flour can be used along with germinated green gram flour to formulate a high calorie dense weaning food having excellent nutritional qualities.
Baking

Baking is the cooking of food by using prolonged dry heat acting by convection, and not by thermal radiation. When desired temperature is reached within the heating instrument, the food is placed inside and baked for a certain amount of time. The term ‘baked products’ is applied to a wide range of food products including breads, cakes, pastries, pies, cookies, crackers and many other products. They all use recipes that are based on wheat flour such as gluten-free products, used by people with coeliac digestive disorders. A part of this can be replaced by malted ragi flour in preparation of baked products. The cake sample supplemented with 50% malted ragi flour has excellent sensory and nutritional properties.

Multigrain flour

Multigrain refers to a food that contains more than one type of grain. Common grains included in multigrain foods include oats, corn, soy, barley, buckwheat, wheat, flax and millet (finger millet (*Eleusine coracana*), proso millet (*Panicum miliaceum*), little millet (*Panicum sumatrense*), foxtail millet (*Setaria italica*), barnyard millet (*Echinochloa crusgalli* and *E.colona*), kodo millet (*Paspalum scrobiculatum*). This whole grain blend incorporates the bran, germ, and endosperm portions of the grains to make nutritious flour. This blend may be used for preparation of suitable value added products.
### List of equipments to be used

<table>
<thead>
<tr>
<th>Large scale</th>
<th>Small scale</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Germinator</td>
<td>1. Domestic grinder</td>
</tr>
<tr>
<td>2. Dryer</td>
<td>2. Sprout maker / Domestic method using wet cloth</td>
</tr>
<tr>
<td>3. Grinding mill</td>
<td></td>
</tr>
<tr>
<td>4. Mechanical sieve</td>
<td>binding</td>
</tr>
<tr>
<td>5. Hot air oven</td>
<td>3. Hand sieve</td>
</tr>
<tr>
<td>6. Packaging unit</td>
<td>4. Domestic oven</td>
</tr>
<tr>
<td></td>
<td>5. Hot plate sealer</td>
</tr>
</tbody>
</table>

### Size reduction

Size reduction refers to the operation wherein particles of solids are cut or broken into smaller pieces. Hammer mills are mostly impact grinders with swinging or stationary steel bars forcing ingredients against a circular screen or solid serrated section designated as a striking plate. Material is held in the grinding chamber until it is reduced to the size of the openings in the screen. The number of hammers on a rotating shaft, their size, arrangement, sharpness, the speed of rotation, wear patterns, and clearance at the tip relative to the screen or striking plate are important variables in grinding capacity and the appearance of the product. Attrition mills impart a shearing and cutting action. Grinding is done between two discs equipped with replaceable wearing surfaces. One or both of these discs is rotated; if both, they rotate in opposite directions. When one disc is rotated, and the other stationary, the assembly is used for shredding and deferring. Often materials which have been coarsely ground by other mills, are passed through an attrition mill for blending or smoothing out an ingredient.

![Value added products from ragi](image_url)  
**Fig. 27 Value added products from ragi**

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(List of equipments to be used continued on next page)

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(Element of equipments to be used continued on next page)
There is a scope for preparation of a number of value added nutraceutical products from dehydrated germinated ragi and blended ingredients at affordable price. By diversified utilization of ragi, market demand for the crop can be enhanced. The continuous decline in the ragi production in the state has become a matter of concern and need has arisen to promote this highly nutritious crop. There is a necessity for motivation of increasing area under ragi cultivation by popularizing the value added products of ragi in order to supplement nutraceutical components to the human diet.

Dr. (Mrs.) Kalpana Rayaguru
Assoc. Professor
Post harvest processing of pulses

Pulses are one of the main sources of protein for vegetarians. Odisha produces about 10 lakh MT of pulses per year. Different pulses like Pigeon pea (Arhar), Blackgram (Urad), Lentil (Masoor), Greengram (Moong) are grown in different parts of our state. Only 56-70% of the production is available for food use and rest goes as seed and milling and other losses. The primary processing activities of pulses such as cleaning, drying, grading and storage are followed by farmers in traditional methods. The common products from pulses are polished whole pulse, splitted dal, roasted pulses, fried products, food mixes (sattu), badi, papad and Ready-to-eat extruded products. Processing and value addition of pulses can generate gainful employment to rural youth.

Whole dhal processing by cleaning and grading

Whole grains after proper drying can be cleaned, graded and packaged for market supply. Some pulses are polished after cleaning and grading and marketed as whole pulse. Polishing adds lustre to the dal. This involves either removal of dust from grain surface or application of some edible oil on the grain surface.

Equipments required

1. Bucket Elevator
2. Screen Grader, Model 18 x 36 III deck type with aspiration system
3. De-stoner
4. Polisher/Worm mixer
5. Weighing and bagging machine

Dal milling

It is a domestic activity in rural areas at household level and hand stone grinder (Chakki) is used to dehusk and split dal. More than 80% of the pulses are processed in the commercial dal mills and consumed in the form of dal. In Orissa, major dal mills are located in different districts like Ganjam, Khurda, Sambalpur, Baragarh and Cuttack. Collection of whole pulses from the farmers and milling of the items is a profitable industrial activity. There exists very good scope to set up such milling units in urban as well as rural areas of the state to meet the growing demand. As the raw material is costly, this kind of industrial activity requires heavy working capital.
Pulses are milled in commercial dal mills with 4-30 q/h capacity in large scale. Different research organizations (CFTRI, PKV, CIAE) have also developed dal mills for cottage scale processing having capacity of 0.5-2.0 q/h. Different aspects of pulse processing include machine parameter, grain parameter and pre-milling treatment.

**Unit operations of pulse milling**

- Cleaning to remove foreign materials and grading to mill each grades separately for avoiding breakage during milling.

- Conditioning
  Pre-milling treatment of pulses makes it suitable for easy removal of husk. The kernels of hard to mill pulses (green gram, black gram, red gram) are tightly attached to husk due to presence of some gums. The pre-milling treatment of pulses includes wet milling, dry milling and dry heating.

  **Easy to mill pulses:** Bengal gram, lentil, peas

  **Wet milling method:** Soaking in water
  Drying under sun and heaped at night

  **Difficult to mill Pulses:** Red gram, green gram, black gram

  **Dry milling method:** Pitting or scratching
  Oil mixing (400-600 g/q) and heaping
  Sun drying, 2-4 days
  5-7 % water application and tempering

- Dehusking
- Husk separation
- Splitting
- Grading
- Polishing
- Packaging

**Equipments**

1. Cleaner and grader (Rotary screen/ Flat screen)
2. Abrasive roller mill (Cylindrical/Tapered)/Stone chakki
3. Worm mixer
4. Dryer (Mechanical/ Sun)
5. Husk fan
6. Splitting machinery (Attrition mill/ Roller/ Impact splitter)
7. Grader (Flat screen)
8. Brush type polisher
9. Bucket elevators
Operation

After cleaning and grading, dal is passed through the roller 2 times for scratching. Then oil @400-600 g /q is mixed in screw type worm mixer and tempered overnight. After drying under sun for 2 days or in the dryer at 60°C for 3 h, water @5-7 % is mixed to the heated dal and tempered for 6 h. Again it is passed through the roller mill for dehusking and husk is removed by fan. The milled dal is graded to separate gota and splitted dal. The gota of mung dal is passed though the splitter machine. The milled dal is polished in the polisher with powder and water treatment, packed in gunny bags for market supply.

Other pulse based enterprises
• Bengal gram and peas are consumed in roasted form. The unit operations involved in roasting are cleaning, grading, moistening, roasting, puffing, splitting, husk separation, grading and packaging. Heating of grain is done by saw dust, rice husk, groundnut shell and agricultural waste. Fried pulses can be obtained after soaking and frying.

• Besan making consists of size reduction (Pulveriser/Attrition mill), flour sifting followed by packaging. It is used for preparation of pulse based sweet dishes and snacks.

• Badi and papad unit can be promoted at household level.

• Cottage scale pulse processing like whole pulse processing, milling for dal, pulse flour (besan) unit can be started with low initial investment and capacity can be enhanced with time. The facility can be made available on custom hiring basis to consumers.
Different mini dal mills

<table>
<thead>
<tr>
<th>Parameters</th>
<th>PKV, Akola</th>
<th>CIAE, Bhopal</th>
<th>CFTRI, Mysore</th>
</tr>
</thead>
<tbody>
<tr>
<td>Capacity, kg/h</td>
<td>125-150</td>
<td>80-100</td>
<td>80-100</td>
</tr>
<tr>
<td>Pulses to be milled</td>
<td>Pigeon pea, Green gram, Black gram</td>
<td>Pigeon pea, Green gram, Black gram</td>
<td>Pigeon pea, Green gram, Black gram</td>
</tr>
<tr>
<td>Power requirement</td>
<td>3 hp, Single Phase</td>
<td>2 hp, Single Phase</td>
<td>1-1.5 hp, Single Phase</td>
</tr>
<tr>
<td>Dal recovery, %</td>
<td>75-80</td>
<td>74-75</td>
<td>78-82</td>
</tr>
<tr>
<td>Approx. cost</td>
<td>1,00,000/-</td>
<td>60,000/-</td>
<td>80,000/-</td>
</tr>
</tbody>
</table>

Requirement of a cottage scale dal milling unit (100 kg/h)

<table>
<thead>
<tr>
<th>Equipment</th>
<th>Quantity</th>
<th>Cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Roller mill, 2’ wooden</td>
<td>1</td>
<td>25000</td>
</tr>
<tr>
<td>Oil mixing worm, 8’, MS</td>
<td>1</td>
<td>15000</td>
</tr>
<tr>
<td>Item</td>
<td>Quantity</td>
<td>Price</td>
</tr>
<tr>
<td>-------------------------------------------</td>
<td>----------</td>
<td>-------</td>
</tr>
<tr>
<td>Splitter (phatka), 2’ MS</td>
<td>1</td>
<td>20000</td>
</tr>
<tr>
<td>Cleaner-cum-grader, Wooden 8’x3’</td>
<td>1</td>
<td>30000</td>
</tr>
<tr>
<td>Polisher, 2’ Brush type</td>
<td>1</td>
<td>30000</td>
</tr>
<tr>
<td>Blower fan (wooden)</td>
<td>1</td>
<td>20000</td>
</tr>
<tr>
<td>15 hp Motor</td>
<td>1</td>
<td>30000</td>
</tr>
<tr>
<td>2 hp motor</td>
<td>2 no</td>
<td>15000</td>
</tr>
<tr>
<td>Motor, starter, switch, motor rail,</td>
<td></td>
<td>30000</td>
</tr>
<tr>
<td>pulley, shaft, Belt</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Miscellaneous</td>
<td></td>
<td>15000</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td></td>
<td><strong>2,30,000/-'</strong></td>
</tr>
<tr>
<td><strong>Optional</strong></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Dryer, kerosene fired</td>
<td>1</td>
<td>70000</td>
</tr>
<tr>
<td>Elevator</td>
<td>5</td>
<td>200000</td>
</tr>
</tbody>
</table>

Establishment of agro-processing industries in the rural areas is needed to transform the farmer from merely producer to producer-cum-processor. Setting of viable processing industries in the major producing areas and running it through co-operative societies/groups formed by farmers will enable the producer to get the actual profit. There is also the need for development of large scale processing industries by private farm or co-operative societies for production of export quality products from the available agricultural commodities. This will create market for farmers to sale their commodities as raw material for the large scale industry.

_Dr. Chinmaya Kishore Bakhara_
_Assoc. Professor_
Post harvest processing of oilseeds

Odisha produces about 7 lakh MT of oil seeds per year. Groundnut, sesamum, sunflower and mustard are among the major oil seeds produced in the state. Oil is contained within a range of oilseeds, fruits, nuts and seed kernels. However, not all oil-bearing seeds and nuts contain edible oil. Some contain poisons or unpleasant flavours and are only used for paints and industrial purpose. There is a universal demand for vegetable oils for household cooking, as an ingredient for other food products such as baked goods and snack foods and as a raw material for the manufacture of soap, detergents and body oils. Oil seed contains on an average of 20-45 % oil depending on the product. However, some are used in kernel form or processed kernel in snacks. Groundnut, sesame and sunflower have great potential for food uses. Kernels of groundnut are used after roasting and salting as snack food. Kernels of white variety of sesame are preferred for confectionery.

<table>
<thead>
<tr>
<th>Oil seed</th>
<th>Husk/Hull</th>
<th>Kernel</th>
<th>Oil</th>
</tr>
</thead>
<tbody>
<tr>
<td>Groundnut</td>
<td>25</td>
<td>75</td>
<td>33</td>
</tr>
<tr>
<td>Mustard</td>
<td>18-20</td>
<td>80-82</td>
<td>33-41</td>
</tr>
<tr>
<td>Sesamum</td>
<td>14-18</td>
<td>82-86</td>
<td>40-49</td>
</tr>
<tr>
<td>Sunflower</td>
<td>30-40</td>
<td>60-70</td>
<td>37-42</td>
</tr>
</tbody>
</table>

Oil is contained in plant cells and is released when the cells are ruptured. The method of extracting the oil depends on the composition of the raw material. Some seeds are processed dry while some are processed wet. The process of oil extraction produces a by-product known as oilcake. This is very nutritious and can be used for animal feed or as an ingredient in other food products. There is universal demand for vegetable oil for home use and for use in other food processing operations. Decentralised, small-scale oil processing can bring many benefits to the processor and the local community. Extracted oil is a relatively 'safe' product and if properly processed, oils have a shelf life of up to 6 months.
During oil processing, the raw material (oil seeds or nuts) is heated to destroy any enzymes and micro-organisms that may cause rancidity. The oil may also be heated after extraction to remove as much water as possible which helps to increase the quality of the oil and the potential shelf life. Oils should be stored in a cool place away from direct sunlight and heat to prevent chemical changes that can lead to rancidity.

**Oil milling**
For successful pressing, the seed must be:

**Dry.** Moist seed will lead to low yields and clog the cage (a part of the press). Moist seed may also get moldy.

**Clean.** Fine dust in the seed may clog the cage. Chaff left in the seed will absorb some of the oil and keep it from getting squeezed out of the cage. Sand in the seed will wear the press out. Stones badly damage the piston.

**Warm.** Warm seed will yield the most oil for the least effort.

**Dried before it is bagged and stored.** Very damp seed will feel humid when you bury your hand in it, especially if the seed is warm. If you heat your seed in the sun under a sheet of clear plastic, you may see moisture collecting beneath the plastic if the seed is too wet.

**Unit operations of oil milling**

- **Preparation of raw material by cleaning**
  Cleaning is done for removal of foreign matter and to avoid contamination of products intended for food use. Magnet is advocated to remove ferrous materials.

- **Dehulling**
  De-hulling of oil seeds like sunflower, groundnut is preferred for getting good quality meal for food use. Hulls contain very little oil, they absorb oil during oil expression and reduce oil recovery.

- **Grinding or flaking**
  Seed cracking helps in heat penetration during cooking due to increase in surface area.

- **Heating or conditioning**
  Cooking or hydro-thermal treatment of ground/flaked oil seeds at 70-110° C helps in rupturing oil globules for ease of oozing out and increase of flowability and inactivation of enzymes/ anti-nutritional factors/ toxic substances

- **Oil expelling**
For easy movement of materials in the oil mill, some husk percentage is desirable. The cake obtained through only mechanical expression has dark colour and poor protein quality due to exposure to excessive heat.

- Clarification and filtration
- Packaging

**Equipments required**

The equipment needed to set up a small or medium scale oil extraction enterprise falls into three main categories:

a) Pre-extraction equipment: Dehullers, Seed/ kernel crackers, Roasters
b) Extraction equipment: Manual presses, Ghanis, Screw press/oil Expellers
c) Equipment for basic refining of the oil: Filters, Settling tanks.

**Oil expression/ extraction methods**

The oil is obtained from oil seeds by three methods.

a. Full pressing with high pressure screw press for material exceeding 20% oil content
b. Direct solvent extraction for oil seeds with less than 20% oil
c. Combination of pre-pressing of oil seeds containing higher percentage of oil in a low pressure screw press followed by solvent extracion

**Mechanical expression**

Ghanis are used earlier for oil expression at rural level in cottage scale. Screw press and oil expellers are used in cottage scale for expression of oil from oilseeds. The four basic stages which influence the pressing efficiency in screw press are

- Raw material preparation
- Pre-treatment/ Cooking
- Screw pressing and separation of oil
- Return of meal/cake to screw press
Fig. 33 Oil screw press

Fig. 34 Decorticator

Fig. 35 Oil expeller
Operation

After cleaning of seed, it is decorticated and graded. The seed is dried under sun. Then the seed is fed to the expeller hopper where it is initially heated by steam. Then the seed is pressed in the expeller. The pressed oil is then passed through a filter press for filtration of fine particles. The oil is then supplied to a refining unit for processing, packaging and marketing.

Preparation of raw material

- Oilseeds and nuts should be properly dried before storage and cleaned to remove sand, dirt and other contaminants, handled carefully to reduce bruising and splitting.
- All raw materials should be sorted to remove stones and debris. Any mouldy nuts should be discarded as these can cause aflatoxin poisoning.
• Cleaned oil seeds should be stored in cool, dry, ventilated rooms away from birds, insects and rodents.

• Some raw materials (eg sunflower, groundnut) require dehulling (also known as dehusking or decorticating) prior to oil extraction followed by winnowing to remove the husk or seed coat from the kernel by dehulling machines and winnowers (both manual and powered).

• When pressing groundnuts, some of the husk is added back to the groundnut cake during pressing (10% by weight) for making it easier to press the oil.

• Coconut is dehulled and split by skilled operators as this is faster than using a small-scale machine.

• Most nuts need grinding before oil extraction to increase the yield of oil. Small mills are available for grinding copra, palm kernels and groundnuts.

• Groundnuts are ground to a coarse flour either by pounding in a mortar and pestle or using a roller mill. Sunflower seeds are broken using flakers. Hammer mills are used to break palm kernels. Coconut flesh is grated using manual or powered graters.

**Heating or conditioning**

• Wet raw materials such as palm fruit or coconut are heated to break the oil/water emulsion and allow the oil to be separated.

• Groundnuts and sunflower seeds are conditioned by heating with a small amount of water before oil extraction to assist in rupturing the oil bearing cells which allows it to flow more freely.

• The required temperature and moisture content vary according to the raw material.

• Groundnut flour needs 10% added water and is heated to 90°C in a seed scorcher. Heating is complete when the mixture stops sticking together and forms a free flowing flour.

**Extraction**

• There are three main types of oil extraction: Motorised or animal powered ghansis; oil presses; oil expellers.

• A ghani consists of a wooden mortar fixed to the ground and a rotating pestle. The raw material is crushed against the side of the mortar as the pestle is rotated. Oil is pressed out of the oil seed and runs through a hole at the bottom of the mortar where it is collected.

• Raw materials are placed in a heavy perforated or slotted cage and a metal plunger is used to press out the oil. The main
difference in the design is the method used to move the plunger, which can either be a screw thread or a hydraulic jack.

- Oil expellers have a horizontally rotating screw which feeds raw material into a barrel-shaped outer casing with perforated walls. The expeller grinds, crushes and presses out the oil as the oil-seed passes through the machine. Oil flows through the perforations in the casing and is collected underneath. The residue or oilcake is pushed out of the end of the unit.
- For maximum efficiency, the screw should fit tightly within the casing and therefore requires repair or replacement at frequent intervals since it gets abrasion from the seeds.

**Clarification and filtration**

- Crude extracted oil contains a range of contaminants including fine pulp and fibre from the plant material, small quantities of water, resins, colours and bacteria which make it dark in colour.
- The contaminants can be removed by clarifying the oil and a clarifier can be used.
- The crude oil can be left to stand for a few days and then the upper layer is removed.
- If further clarification is needed, the oil can be filtered through a fine filter cloth. After filtering, the oil is heated to boil off traces of water and destroy bacteria.
- When all impurities are removed, the shelf life of the oil can be extended form a few days to several months, provided it is stored properly.

**Packaging**

- Use clean, dry, airtight and moisture-proof containers to package and store oils in a cool, dark location to ensure a long shelf-life.
- Retail-size sealed glass or plastic bottles are adequate for small quantities. Colored containers in a dark box help increase shelf life. Steel or plastic tanks work well for large quantities.
- The shelf life of oil is usually six to 12 months if it is properly packaged and kept away from heat and sunlight.
- Keeping air away from oil is perhaps the most important step to prevent rancidity. Completely fill whatever size container you chose so there is no air space and then cap the container tightly.
- Shelf life of oil may vary depending on the type of oil as well as the storage conditions and amount of poly-unsaturates present.
If the stored vegetable oil does not reach sustained temperatures of 100° F or more, its vital components will be preserved. As long as the oil is stored in a dark, cool place, it will have a long shelf life.

Table Oil mill crushing capacity 3 tonnes oilseeds in 24 hours

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Description</th>
<th>Qty</th>
<th>Cost (Rs.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>01.</td>
<td>Oil Expeller chamber size 22”x 4” crushing capacity 100 TO 125 kg./hr. complete</td>
<td>1</td>
<td>100000</td>
</tr>
<tr>
<td>02.</td>
<td>Round automatic feeding / cooking kettle</td>
<td>1</td>
<td>30000</td>
</tr>
<tr>
<td>03.</td>
<td>Filter press 16”x16”-16 plates complete</td>
<td>1</td>
<td>50000</td>
</tr>
<tr>
<td>04.</td>
<td>Baby boiler complete with chimney</td>
<td>1</td>
<td>50000</td>
</tr>
<tr>
<td>05.</td>
<td>Accessories i.e. pipelines, beltings, valves, pulleys, base frame etc.</td>
<td>1</td>
<td>20000</td>
</tr>
<tr>
<td>06.</td>
<td>Essential spare parts</td>
<td>1</td>
<td>20000</td>
</tr>
<tr>
<td>07.</td>
<td>Groundnut decorticating with 2 HP, 1440 RPM motor OR copra cutter with 3 HP, 960 RPM motor complete</td>
<td>1</td>
<td>40000</td>
</tr>
<tr>
<td>08.</td>
<td>Electric motor 10 HP, 3 phase 960 RPM with L &amp; T make starter</td>
<td>1</td>
<td>40000</td>
</tr>
<tr>
<td></td>
<td><strong>Total</strong></td>
<td></td>
<td><strong>350000</strong></td>
</tr>
</tbody>
</table>

Solvent extraction

- The most widely accepted large scale oil processing method is solvent extraction method for complete extraction of oil.
- The solvent (Hexane) is sprayed over a bed of flakes and allowed to flow through flakes to extract the oil.
- The mixture of oil in solvent called as miscella containing 20-25% oil is heated to 83 C in evaporators to vaporize the hexane to 5% level.
- Then oil is directly steam-stripped in a vacuum tower at 110C for hexane recovery.
- De-solventisation is done to remove and recover the solvent adhered to extracted flake. Residual hexane in de-oiled cake is toxic and undesirable.
- Good quality meal is obtained for food preparation.
Food use of de-oiled cake

- Oil seed cake is used for human consumption in the form of flour, protein concentrate and textured vegetable protein.
- In screw press extraction, pressure is kept as low as possible to avoid high frictional temperature and resultant damage to both oil and cake. The cake is also used for poultry and cattle feed.
- Cereal based extruded snack foods, food mixes (sattu), sweets like laddus can also be prepared from oil seed.

Refining of oil

In many local markets further refining is not required as the complex flavours of unrefined oils are preferred. International markets tend to prefer lighter less intense oils for cooking which means further processing of the oil. There is a series of refining processes that can be carried out after the oil has been filtered.

**De-gumming.** Degumming is a way of treating seed that have a high phosphotide content. The phosphotide, which makes a gummy residue, is removed by mixing the oil with 2 or 3% water. This hydrated phosphotide can then be removed by settling, filtering or centrifuged.

**Neutralisation.** Fatty acids can be neutralised by adding a sodium hydroxide solution, also known as caustic soda, or by stripping, which is a similar process to de-odorising.

**Bleaching.** Some oils have a very dark colour that is unpopular with consumers. The appearance of the oil can be lightened by bleaching.

**De-odorisation** Volatile compounds that produce bad odours can be eliminated through the process of sparging, i.e. bubbling steam through the oil, under a vacuum.

**Winterisation** Allowing the oil to stand for a time at low temperatures so that glycerides, which naturally occur in the oil, with higher melting points solidify and can then be removed from the oil by filtering. Over time glycerides can degrade releasing fatty acids into the oil increasing the acidity levels and reducing the quality.

Some other pulse-oil seed based processing industries

1. Extruded product processing
2. Weaning food processing
3. Snack food processing like mixture and sweets
4. Flour mill for Besan, sattu etc
5. Roasted/Puffed product processing
6. Feed plant from the by-products of dal and oil mills
7. Seed processing plant
8. Badi and pappad processing unit

Smaller scale decentralised oil extraction can prove to be economic and provide opportunities for income generation. The common opportunities exist where:

- Oil produced in the large refineries does not find its way out to more remote and distant rural areas.
- High transport costs are involved in wide distribution of cooking oil so increasing the price of oil.
- Small farmers produce oilseeds such as groundnuts for sale to the large refineries which they then buy back, at high cost, in the form of cooking oil but without the valuable high protein oil cake.
- The crude oil is used to produce added value products, most commonly soap.

The viability of any oil extraction enterprise depends to a considerable extent on the sale of the oil cake for use in animal feeds and other sub-products. Markets for oil cake must be investigated and demand established before starting the enterprise.

Dr. Uma Sankar Pal
Assoc. Professor
Extrusion cooking

The verb “to extrude” derives from Latin word ex (out) and trudate (to thrust) & means to force as through small openings. Extrusion cooking is a process whereby raw feed material is exposed to controlled conditions of high temperature, pressure, shear and moisture. An extruder is a machine which shapes materials by the process of extrusion. A food extruder is a versatile machine capable of performing operations like mixing, kneading, shearing, heating (cooking), shaping and forming etc. Extrusion cooking combines the heating of food products with the act of extrusion to create a cooked and shaped food product. Extrusion cooking can also be described as a process whereby moistened, starchy, and/or proteinaceous foods are cooked and worked into a viscous, plastic like dough.

The advantages of extrusion cooking lies in continuous processing facility using numerous ingredients and processing conditions (Versatility) in an energy efficient way (Reduced costs), High production rates and No effluents. The labour and floor space requirements per unit of production are less than for other cooking / forming systems enhancing cost effectiveness.

Typical Food Products Produced by Extrusion Technology

- Pasta
- Ready-to-eat (RTE) cereals
- Snack Products
- Pet foods : Dry and semi moist
- Confectionary foods
- Precooked and modified starches
- Breading substitutes
- Beverage bases
- Texturized proteins : Meat analog, fish paste (Surimi)

How an extruder works?

In an extruder food is heated in the barrel by Steam, Electric induction and Friction by the product is caused by Screw and barrel ribs. Compression of product is increased by increasing screw diameter and decreasing pitch, tapering barrel with constant or decreasing screw pitch, placing restrictions in screw flights. Back pressure is created by compression, die. High pressure and small die used to produce expanded product and Low pressure and /or large die produce high density products.
Fig. 39 Single screw extruder

Uses of extruder in Industry to produce Pasta products
Pasta production e.g. macaroni and spaghetti relies mainly on the process of cold extrusion. Low temperatures and pressure are needed in this process to keep the pasta from cooking.

Uses of extruder in Industry to produce snacks products
The production of snack products via extrusion process is a rapidly growing area. High temperatures and pressures are necessary to produce the snacks. Here the gelatinised starch ensures that when the mixture expands by going from high pressure to low pressure it holds its expanded shape. Varieties of spices and condiments are used to give diverse range of expanded snacks food products.
Consumer acceptance and texture of foods is mainly due to the convenience, value, attractive appearance and texture found to be particular for these foods, especially when it concerns snack products, though it doesn’t have much of health ingredients. The pastas and expanded snacks products produced by this process are not very healthy as they largely composed of starchy materials and devoid of other nutrients. Now a day’s dietary fiber is receiving increased attention, as consumers are becoming more concern about eating food with healthy benefits. The major role of the starchy ingredients is to give structure, texture, mouth feel, bulk and many other characteristics desired for finishing product. Among other material, vegetable fiber incorporation of has shown to cause a positive impact on levels of dietary fiber.

*Dr. Nihar Ranjan Sahoo*

*Assoc. Professor*
Storage of food grains and its management

Storage is one part of the post-harvest system through which food material passes on its way from field to consumer. Storage is a batch of grains or crops kept relatively in an isolated condition artificially created by man. It may be defined as a thermodynamic system which includes a group of interacting organisms and their surrounding environment and characterized by set of bio-physio-chemical properties.

Loss is a measurable decrease of the foodstuff which may be quantitative or qualitative. Losses occurring during storage are affected by conditions prevailing in the pre-storage stages (harvesting, threshing and drying). Post-storage losses may be affected by conditions during storage. High temperatures, high relative humidity and high moisture contents of stored produce are favourable to the development of pest organisms. Respiration is a self-accelerating process upon slight increase in temperature, RH and moisture content which results in further increase in temperature and moisture content and also biodeterioration. High relative humidity leads to a rise in the moisture content of the stored produce and under certain conditions to condensation. If no measures are taken to counteract this, considerable losses are likely to occur. The quality of the stored produce can be maintained through necessary steps like drying of the produce, good storage hygiene, controlled ventilation and pest control. Pest organisms, comprising insects and mites among invertebrates; birds and rodents among vertebrates; and microorganisms including fungi, yeast, and bacteria, cause degradation of grains in storage. The interaction of all the pests in the grain ecosystem has a cumulative effect on the grain quality and thus leads to qualitative, quantitative, and nutritive losses.

Grain protection
Most of the micro-organisms thrive between 10 and 60°C temperature whereas insects between 16 and 45°C. Normally, in tropics and subtropics storage temperature lies between 25 and 35°C which is favourable for the survival of the micro-organisms and insects. All micro-organisms, including moulds, require moisture to survive and multiply. If the moisture content in a product that is to be stored is low, micro-organisms will be unable to grow, provided that the moisture inside the storage structure is also kept low. Moisture
should therefore, be pre-vented from entering the store. It has been established that most insects do not thrive below 9 percent moisture content of the grains. So, it is essential that before grains are put into storage, the moisture level should be 8 percent and absorption of the moisture from the air should be prevented. With relative air humidity below 65-70 percent, many grain-degradation phenomena are slowed down, if not completely blocked. In this sense, the "safe storage" moisture content is defined as that corresponding to equilibrium with the air at 65-70 percent relative humidity at safe storage temperature.

Control measures

- **Temperature**: Ventilation, Insulation, Refrigeration
- **Relative humidity**: Ventilation, Insulation, dehumidification
- **Moisture content**: Ventilation, Moisture proofing, Dehumidification, Sealed containers, Desiccants.
- **Fungal activity**: A low and uniform moisture content & temperature can effectively control fungal growth, use of chemicals
- **Insects**: Temp. above 25°C is unfavorable for their reproduction, By reducing the grain moisture to 12%. By reducing the oxygen conc., Under carbon dioxide & Nitrogen atmosphere insects activity can be eliminated, Use of chemicals and fumigants are necessary at times.
- **Rodents**: Rat proofing & trapping, By using poisons, repellants, fumigant, By using pneumatically generated ultrasonic waves.

The duration and type of storage is of vital importance in deciding the most appropriate storage practice. Thus, storage can be:

**Transit**: The best method will be to have proper go downs with permanent cubicles in which the bagged grain can be suitably stacked. These cubicles should be constructed so that they can be made air-tight both for storage and fumigation. This would provide ideal storage conditions and also the necessary handling facilities for bags needed for transit storage.

**Short term**: This type of storage is practised by cultivators who generally like to store their seed/grain from harvest to sowing and foodgrains from harvest to harvest. Storage structures generally used for short-term are traditional farm level structures of non-airtight bulk storage.

**Long term**: Air-tight bulk storage is best if the stock has to be maintained on a long-term basis. It is generally in the form of warehouses or modem silos above ground. Bag storage structures
housed in storage godowns are permanent means of long-term storage. The cost of such storage is quite less in the long run. The godowns should have adequate provision for making the whole structure sufficiently air-tight for fumigation and proper aeration after fumigation. This can be easily managed by having ventilation fitted with proper exhaust fans and also a suitable arrangement for closing the ventilator air-tight.

**Bulk storage:** Bulk storage is preferable for wheat, paddy, barley, gram and other coarse grains. To take full advantage of bulk storage the grain should be free from insect infestation, well dried and should be stored in damp-proof and uninfested bins. If infested, grain in bulk can be fumigated at a low cost to prevent further deteriorations and cross-infestation of uninfested stocks. Bulk storage leads to considerable economy in storage space, its maintenance and the cost of gunny bags.

**Bag storage:** Bag storage is largely practiced in the trade go downs, mainly because of the ease in handling and transport. Bagged grain should be stacked on racks, at least 30 cm from the walls of the warehouse and far enough apart to allow inspection and cleaning. Infested bags, if any, can be easily segregated and treated.

**Types of storage systems/structures**

- **Traditional**- Structures used by farmers using traditional materials and local skill, (Underground storage, Straw storage, Bamboo storage (Doli), Wooden storage, Mud Storage, Gunny storage, Metal bin storage
- **Improved**- Concrete bin, Plywood bin, Metallic bins, Ferro cement bin, Unitized clay ring, Dehydro bin, Pusa bin, CAP (Cover and Plinth) storage
- **Modern**- Expensive system using some modern technique: Air tight (hermetic), Low temperature storage, Low temperature and dehumidified, High temperature storage, Modified atmosphere/ controlled atmosphere storage.

Low cost measures to improve the performance of Traditional storage structures in Odisha.

- Under ground- RCC/brick floor, walls. Coal tar/polyethylene sheet-smooth surface to prevent rat entry and rain water penetration.
- Straw storage- Water proofing floor and mud plaster
- Bamboo storage-Wooden platform, inverted metal cone legs, 1:4mortar plaster,
- Wooden storage - Creosote painting. Fixing metal sheet at bottom
✓ Mud storage- Stabilized clay, concrete skirting, water proof coat
✓ Gunny bag- Raised platform, polyethylene sheet living, insecticide spraying,
✓ Metal bin- Bright painting, Insulation

Cap storage: (Cover and Plinth): This is an improvised arrangement for storing food grains in the open, generally on a plinth which is damp- and rat-proof. The grain bags are stacked in a standard size on wooden dunnage. The stacks are covered with 250 micron LDPE sheets from the top and all four sides. Food grains such as wheel, maize, gram, paddy, and sorghum are generally stored in CAP (cover and plinth) storage for 6-12 month periods. It is the most economical storage structure and is being widely used by the FCI for bagged grains.

Pusa bin: The Pusa Bin which is used for storage of foodgrains at farm level was developed by Indian Agricultural Research Institute (IARI), New Delhi. It is a LDPE (Low density polythene sheet) sandwiched bin. Upto 10 MTs grain can be safely stored in this bin.

Hermetic sealed storage: Sealed or hermetic storage systems are very good to control grain moisture content and insect activity in tropical regions. Hermetic means there is no contact with the outside air. Once the container is hermetically sealed the moisture content of the grain will be controlled. Respiration by the grain and insects inside the storage container change the inter-granular atmosphere by consuming oxygen and producing carbon dioxide. It minimizes biological activity inside the storage container hermetic storage also helps maintain quality.

Safe storage practices
✓ A clean, dry and cool store together with clean and dry grain are the first and most important steps to successful storage of grain.
✓ Before storage the grains should be cleaned and graded. Unclean grain contains small amounts of straw, weed seeds and dirt, which not only decrease the value of food-grains but also cause the grains to deteriorate during storage.
✓ No food-grains with moisture content higher than the safe acceptable level should be accepted for storage. Dry the moist grain before storage because, it respires more quickly and gives off more heat and moisture, which encourages build of insect population and mould growth and hot spots develop in bulk grains.
✓ The grains should be spread over plastic sheets or cemented floor while drying, otherwise it will pick up the moisture from
the ground. The grains should be kept cool and dry between the time of harvest and storage.

✓ Preventive and curative measures are to be taken as and when necessary.

**Pest control at farm level**

- Traditional methods of pest control will certainly continue to play a role in small farm storage in the future. These are cheap and easy. However, their effect is limited.
  ✓ Preventive measures taken before harvesting
  ✓ addition of various substances to the stored produce: Admixture of Mineral substances, and of plant and animal origin
  ✓ Physical methods: Sieving, Winnowing, Moving the grain (shaking, restacking), use of heat, smoking

- Chemical methods: In order to minimize the risk of damage being caused, precautonary measures must be strictly adhered to when dealing with insecticides. Even apparently inconsequential violations of safety regulations may have serious results, many of which will not be immediately recognizable. When treating produce with insecticides, it is particularly important that the user is protected.

**List of precautions for warehouse stored product management**

- Keep all lots stored or stacked separately and clearly marked to enable it to be isolated within an individual lot.
- Rotate stock to minimize the time any product will remain under storage.
- Maintain a warehouse climate at optimal storage temperature and humidity.
- Maintain a sound building with no leaks, damp spots, gaps, holes, or uncontrolled openings.
- Reseal or repair any damaged or opened bags as soon as possible.
- Clean up any spilled grain quickly and discard away from the premises.
- Keep all stacks of grain 12 to 18 inches away from any wall to allow ventilation and limit stack height against mechanical damage to allow easy inspection.
- Remove all bird nests and prevent roosting and access of birds to the building.
- Make routine inspections as often as every two weeks and no less frequently than monthly looking for any of the spoilage signs by rodents and insects.
• Rodent traps, light traps, and pheromone traps may be used to help monitor the presence of pests.
• Before any control measures are taken, be sure pest is accurately identified.
• If fumigation becomes necessary, it should be performed by a pest control operator holding a fumigation license or employee holding fumigation certification. Select appropriate fumigant that will not affect seed germination.

Storage is an important link in the entire procurement and distribution system of food grains which are produced seasonally but are consumed all the year round. It helps in reducing the seasonal fluctuations in availability and prices. Scientific storage is essential to reduce the food grain losses. Therefore, planning is to be made for storage requirement at macro-level to take care of regional imbalances and the needs of people on micro-level basis.

Dr. (Mrs.) Kalpana Rayaguru
Assoc. Professor
Food laws, regulations and quality

To meet a country’s sanitary and phytosanitary requirements, food must comply with the local laws and regulations to gain market access. These laws ensure the safety and suitability of food for consumers, in some countries; also govern food quality and composition standards. The requirement of food regulation may be based on several factors such as whether a country adopts international norms developed by the Codex Alimentarius Commission of the Food and Agriculture Organization of the United Nations and the World Health Organization; good agricultural and manufacturing practices; or a country may also have its own suite of food regulations. Each country regulates food differently and has its own food regulatory framework. Usually more than one agency is involved in food regulations e.g. health and agriculture, they may have centralized or regionally controlled food regulations, and different agencies may be involved in enforcement activities.

Food safety and standards act

The Indian Parliament has recently passed the Food Safety and Standards Act, 2006 that overrides all other food related laws. It will specifically repeal eight laws:

- The Prevention of Food Adulteration Act, 1954
- The Fruit Products Order, 1955
- The Meat Food Products Order, 1973
- The Vegetable Oil Products (Control) Order, 1947
- The Edible Oils Packaging (Regulation) Order, 1998
- The Solvent Extracted Oil, De oiled Meal, and Edible Flour (Control) Order, 1967
- The Milk and Milk Products Order, 1992
- Essential Commodities Act, 1955 relating to food

The Act establishes a new national regulatory body, the Food Safety and Standards Authority of India, to develop science based standards for food and to regulate and monitor the manufacture, processing, storage, distribution, sale and import of food so as to ensure the availability of safe and wholesome food for human consumption. All food imports will therefore be subject to the provisions of the Act and any rules and regulations made under the Act.
Voluntary standards
There are two organizations that deal with voluntary standardization and certification systems in the food sector. The Bureau of Indian Standards looks after standardization of processed foods and standardization of raw agricultural produce is under the purview of the Directorate of Marketing and Inspection.

Bureau of Indian Standards (BIS)
The activities of BIS are twofold the formulation of Indian standards in the processed foods sector and the implementation of standards through promotion and through voluntary and third party certification systems. BIS has on record, standards for most of processed foods. In general, these standards cover raw materials permitted and their quality parameters; hygienic conditions under which products are manufactured and packaging and labelling requirements. Manufacturers complying with standards laid down by the BIS can obtain and 'ISI' mark that can be exhibited on product packages. BIS has identified certain items like food colours/additives, vanaspati, and containers for packing, milk powder and condensed milk, for compulsory certification.

Directorate of Marketing and Inspection (DMI)
The DMI enforces the Agricultural Products (Grading and Marketing) Act, 1937. Under this Act, Grade Standards are prescribed for agricultural and allied commodities. These are known as "Agmark" Standards. Grading under the provisions of this Act is voluntary. Manufacturers who comply with standard laid down by DMI are allowed to use "Agmark" labels on their products.

Management systems for quality and food safety
The ISO 9000 system is looked at as a system with minimum quality requirements. It builds a baseline system for managing quality. The focus, therefore, is on designing a total quality management system, one that complies with external standards, but includes the specific requirement of industry and integrates elements of competitiveness.

With the advent of FSSAI, the task of bringing different agencies involved in food quality and safety under one umbrella in under process. But as a temporary measure, the standards, safety requirements and other provisions of the repealed Acts and Orders and any rules and regulations made under them will continue to be in force until new rules and regulations are put in place under the Food Safety and Standards Act, 2006. For that reason, importers will
for some time have to continue to take into account the provisions of those repealed Acts and Orders.

**FAQ of food grains**

Promotion of standardization and grading of agricultural commodities is an important aspect of agricultural marketing. The agricultural commodities are heterogeneous and hence it is very essential to grade these commodities as per standards to command better price either at domestic or international market. Sale of grains is offered on the basis of variety, wholesomeness, appearance, colour, presence of foreign matter, damaged grains, broken grains, admixture of inferior variety, moisture, harmful contaminants, etc. A quality grain is that which meets the end user specifications with respect to range of pre-determined Quality and Safety standards.

**Important parameters responsible for quality**

- Wholesomeness, appearance, colour,
- Foreign matter (organic and inorganic)
- Damaged grains
- Broken grains
- Immature/Shriveled grains
- Weeviled grains
- Wheat of other variety
- Other food grains
- Moisture content

**Following SAFETY parameters are important:**

- Pesticides residue
- Poisonous/Heavy metals
- Aflatoxin
- Uric acid
- Microbial load

**Foreign matter**: Includes inorganic and organic matter. The inorganic matter shall include sand, gravel, dirt, pebbles, stones, glass and metallic pieces, lumps of earth, clay and mud. Organic matter shall include husk, chaff, straw, weed seed and other inedible grains. Paddy shall be considered as foreign matter in commodities other than paddy.

**Other food grains**: Foodgrains other than the grain under consideration.
**Damaged**: Kernels or pieces of kernels that are sprouted or internally damaged as a result of heat, moisture, weather or microbes.

**Slightly damaged**: Kernels or pieces of kernels that are damaged or discoloured, superficially so as not to affect the quality of the material.

**Brokens**: Pieces of sound kernels that are less than three-fourths of the size of the full kernels. In case of dals, pieces that are less than the size of three-fourths of the split pulses shall be considered as brokens.

**Immature**: Kernels or pieces of grain kernels that are not fully developed.

**Weeviled Grains**: Weeviled grains are grain kernels that are partially or wholly bored by insects injurious to grain but do not include germ-eaten grains and egg-spotted grains.

**FAQ of paddy**

Paddy shall be sound merchantable condition, dry, clean, wholesome of good food value, uniform in colour and size of grains and free from moulds, weevils, obnoxious smell, Argemon Mexicana, Latharus sativus (Khesari) and admixture of deleterious substances.

**Schedule of specification**

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Refractions</th>
<th>Max. limit %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Foreign matter</td>
<td></td>
</tr>
<tr>
<td></td>
<td>a) Inorganic</td>
<td>1.0</td>
</tr>
<tr>
<td></td>
<td>b) Organic</td>
<td>1.0</td>
</tr>
<tr>
<td>2.</td>
<td>Damaged – discoloured, sprouted and weeviled grains</td>
<td>4.0</td>
</tr>
<tr>
<td>3.</td>
<td>Immature, shrunken and shriveled grains</td>
<td>3.0</td>
</tr>
<tr>
<td>4.</td>
<td>Admixture of lower class</td>
<td>7.0</td>
</tr>
<tr>
<td>5.</td>
<td>Moisture content</td>
<td>17.0</td>
</tr>
</tbody>
</table>

BIS method of sampling to be followed. With overall limits of 1% for organic foreign matter, poisonous seeds shall not exceed 0.5% of which nDhatura and Akra seeds not to exceed 0.025% and 0.2% respectively.
FAQ of wheat

<table>
<thead>
<tr>
<th>Sl.No.</th>
<th>Refractions</th>
<th>Max. limit %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Foreign matter</td>
<td>0.75</td>
</tr>
<tr>
<td>2.</td>
<td>Damaged – discoloured, sprouted and weeviled grains</td>
<td>2.0</td>
</tr>
<tr>
<td>3.</td>
<td>Other food grains</td>
<td>2.0</td>
</tr>
<tr>
<td>4.</td>
<td>Slightly damaged grains</td>
<td>6.0</td>
</tr>
<tr>
<td>5.</td>
<td>Shrivelled and broken grains</td>
<td>7.0</td>
</tr>
</tbody>
</table>

1. Moisture in excess of 12% and upto 14% will be discounted at full value. Stocks containing moisture in excess of 14% are to be rejected.
2. Within the overall limit specified for foreign matter, the poisonous weed seeds shall not exceed 0.4% of which Dhatura and Akra (Vicia species) shall not be more than 0.025% and 0.2% by weight respectively.
3. Kernels with glumes will not be treated as unsound grains. During physical analysis the glumes will be removed and treated as organic foreign matter.
4. Within the overall limit specified for damaged grains, ergot affected grains shall not exceed 0.05%.
5. In case of stocks having living infestation, a cut at the rate of Rupee one per quintal may be charged as fumigation charges.

Quality Standards for pulses

In India, there are no quality standards, for pulses as yet. Most pulses are classified as FAQ “Fair to Average Quality” which is the only approved grade in the Indian market system. This grade however is not standardized and consequently traders assess the grain by visual inspection of colour, texture and size. Moisture content is an important consideration while importing pulses.

International quality standards and grading system for pulses

As India has not formulated any standards as yet, the traders generally accept “fair to average” FAQ: quality. However the quality standards those are essential and are incorporated in the sales contracts are: presence of foreign matter (%), size of the grain, percentage of damaged, discolored, and weeviled grains as well as other seeds, moisture content, colour of the grains, etc.
Quality specifications for Pigeon Peas (Arhar/Toor) are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign Matter</td>
<td>1.0%</td>
</tr>
<tr>
<td>Weeviled Seeds (Material should be free from live infestation)</td>
<td>2.0%</td>
</tr>
<tr>
<td>Damaged (Including immature, shriveled, heated fungi, discoloured grain)</td>
<td>4.0%</td>
</tr>
<tr>
<td>Sister Beans</td>
<td>3.0%</td>
</tr>
<tr>
<td>Brown seeds</td>
<td>3.0%</td>
</tr>
<tr>
<td>Small Seeds (Passing through 3.00 mm slotted sieve)</td>
<td>5.0%</td>
</tr>
<tr>
<td>Moisture</td>
<td>12.0%</td>
</tr>
</tbody>
</table>

Quality specifications for Urad are as follows:

<table>
<thead>
<tr>
<th></th>
<th>Max.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Foreign matter</td>
<td>1.0%</td>
</tr>
<tr>
<td>Weeviled seeds (Material should be free from live infestation)</td>
<td>0.5%</td>
</tr>
<tr>
<td>Damaged (Including immature, shriveled, heated fungi and discolored grain)</td>
<td>2.0%</td>
</tr>
<tr>
<td>Brown seeds</td>
<td>2.5%</td>
</tr>
<tr>
<td>Small seeds (passing through 3.25 mm slotted sieve)</td>
<td>6.0%</td>
</tr>
<tr>
<td>Moisture</td>
<td>8.5%</td>
</tr>
</tbody>
</table>

General

All the pulses quoted shall be from new crop and shall be sound, clean, wholesome, and free from moulds/fungus, live insects obnoxious smell, artificial colour, admixture of unwholesome substance and should be of reasonable uniform size, shape and colour characteristics. All requirements of plant quarantine (regulation of import into India) Order 2003 or any amendments thereof to be strictly adhered to failing which the consignment will stand rejected. Radioactive contamination, if any, within permissible international limits. Mycotoxin including Aflatoxin not to exceed 0.03 milligrams per kilogram.

FAQ for oilseeds

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Refractions</th>
<th>Niger seed</th>
<th>Sesamum</th>
<th>Sunflower</th>
<th>Groundnut</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>Foreign matter</td>
<td>3</td>
<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>2.</td>
<td>Shrivelled grains</td>
<td>4</td>
<td>3</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>3.</td>
<td>Damaged, discoloured and shrunken grains</td>
<td>5</td>
<td>2</td>
<td>4</td>
<td>4</td>
</tr>
</tbody>
</table>

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Food sanitation and hygiene

Besides ingredient quality, there are also sanitation requirements. It is important to ensure that the food processing environment is as clean as possible in order to produce the safest possible food for the consumer. Food quality also deals with product traceability, e.g. of ingredient and packaging suppliers, should a recall of the product be required. It also deals with labeling issues to ensure there is correct ingredient and nutritional information.

Conclusion

The liberalization of the global trade, and the fact that the consumers in the industrialized and developing countries are more and more demanding food to be not only economical, but also healthy, tasty, safe and sound in respect to animal welfare and the environment, are changing the so far quantity-oriented food production, guaranteeing the nutrient supply for a nation, into an international quality-oriented food market, where commodities, production areas, production chains and brands compete each other. In this context the role of quality, standards, food safety and sanitation and hygiene has taken an important stage.

Dr. Nihar Ranjan Sahoo
Assoc. Professor
Feasibility analysis and preparation of project report

Many a times we are approached by entrepreneurs for technical support as regards to set up a food processing unit. Most often they also seek advice for the preparation of project feasibility report for such enterprises. A project feasibility report is essential if the entrepreneur seeks institutional funding. Therefore, in this section we will discuss the basic steps for the preparation of a project feasibility report.

Feasibility literally means whether some idea will work or not. It knows before hand whether there exists a sizeable market for the proposed product/service, what would be the investment requirements and where to get the funding from, whether and where from the necessary technical knowhow to convert the idea in to a tangible product may be available, and soon. In other words, feasibility study involves an examination of the operations, financial, HR and marketing aspects of a business before the venture comes into existence. We should simultaneously understand the marketing, finance, etc. to have a better idea of the issues involved.

However, the theme is that feasibility is a multivariate concept; that is, a project has to be viable not only in technical terms but also in economic and commercial terms too. Moreover, there always is a possibility that a project that is technically possible may not be economically viable.

Some published project reports are also available. However, if we use these off the shelf project reports, we need to revalidate their assumptions and findings. We have to examine all the facets of the feasibility of the proposed project idea, viz., marketing, technical, financial, economic and legal.

Thus the major steps that involve the preparation of a feasibility report include the following.

- Market analysis
- Financial analysis
- Technical analysis
Economic analysis
Ecological analysis
Legal and administrative

Project report
The findings of the feasibility analysis may be compiled in a project report. A specimen proforma of project report is given below for better understanding of the concept. These findings may be vetted by the independent consultants/ experts. Funding agencies have their own setup for the appraisal of these reports. The idea is that the optimist entrepreneur may have overlooked certain aspects that may have a bearing on the ultimate feasibility of the proposed business idea. It is often felt that financial institutions tend to over emphasize the financial feasibility of the project and do not pay adequate attention to its commercial and economic viability. This security driven approach is forwarded as one of the reasons why some promising ventures are turned down despite their sound techno economic viability.

SPECIMEN PROFORMA OF PROJECT REPORT

I. Particulars of The Enterprise
i) Name of the Product(s)_________Product Code_____
ii) Name of the Unit and Address_______________________________

iii) Telephone No.(if any), Office__________________
     Factory____________________

iv) Name(s) and addresses of the Promoters in Block
     Letters________________________

v) Constitution of the Firm :  Proprietary/ Partnership / Pvt. Ltd. / Co op. Society

vi) Qualification both Academic/ Professional of the
    Entrepreneur(s)
    Name ______________________________________________________
    Qualification ______________________________________________

vii) Production/Working experience of the Entrepreneur(s)
    Name of the Organisation _________________________________
    Items Manufactured _____________________________________
    Period ___________________________
viii) Family background (Please give details of close relations who are in industry/ Business).
Name & Address of the units & Items manufactured

ix) Location/ Proposed locations

x) Name & Address of the bank with which you want to deal with

II Economic Viability & Marketability
i) Introduction (Basic & Presumptions) :
ii) Scope:
iii) Marketability (Please give proposed selling arrangements where the products will be mainly sold & likely buyers):

III Technical Feasibility
i) Manufacturing process (Please give process flow chart).
ii) Please indicate the process which will get done from outside
iii) Specifications (whether proposed to adopt ISI specifications or some other).
iv) Components to be purchased from outside. 
Name of the Components No.
Specifications

v) Installed Capacity Qty Value
vi) Proposed capacity to be utilized Qty Value
vii) Motive power requirements (HP) Approx. Qty Value

IV. Financial Projections
A. Fixed Capital
i) a. Land, Area and Value
b. Building area, value owned/ rented or leased
c. Please mention if some arrangements have been made in this respect.
(Please append the proposed layout plan)

ii) Machinery & Equipment

<table>
<thead>
<tr>
<th>Sl No</th>
<th>Description &amp; Specification</th>
<th>Indigenous/ Imported</th>
<th>Qty</th>
<th>Price</th>
<th>Sale Tax</th>
<th>Int.</th>
<th>Total</th>
<th>Name &amp; address of the Suppliers</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
</tbody>
</table>

( Page 73 )
iii) Testing equipment (with details as above)
iv) Electrification & Installation Charges and Maximum 10% of cost of machinery & Equipment
v) Cost of Tools/ Jigs./ Fixtures/ Mould/ Working tables etc.
vi) Cost of Office Equipments.
vii) Preoperative expenses if any (cost of project preparation, technical knowhow expense, royalties, etc.)

vii) Total nonrecurring expenditure (i + ii + iii + iv + v + vi + vii)

B. Working Capital (per month)
   i) Man power

<table>
<thead>
<tr>
<th>Staff &amp; Labour</th>
<th>Designation</th>
<th>No.</th>
<th>Salary</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Technical</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Office</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Sales</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Others</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Salaries per month</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Perquisites (10 to 20% of Salaries)</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Total Salary</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

   ii) Raw materials (per month on single shift basis including packaging materials)
   a)

<table>
<thead>
<tr>
<th>Name with Specifications</th>
<th>Indigenous/ imported</th>
<th>Qty.</th>
<th>Rate</th>
<th>Total</th>
</tr>
</thead>
</table>

   iii) Other items of expenditure (per month on single shift basis)
   a) Utility
      Power ____________kWh unit@_________ per unit cost Rs.________
      Fuel (steam/ furnace oil ____________tones @ Rs.________ Per tonne
      Water ____________kilo litres ____________per Kl.
      Total Cost of Utilities ____________________________

   b) Advertisement & Publicity
c) Transport

d) Commission to Distributors/ agents

e) Consumable stores

f) Rent (if any where cost of land building is not given)

g) Taxes (other than income tax)

h) Insurance

i) Stationery

j) Postage & Telephone etc.

k) Repair & Maintenance

l) Sales Expenses

m) Other miscellaneous (not give above)

n) **Total overheads (a+b+c+d+e+f+g+h+I+j+k+l+m)**

iv) **Total recurring expenditure (per month) (i+ii+iii)**

Working capital for two/three months (depending upon need or worked out on the banks system of assessment of working capital needs)

\[
2/3 \times \text{(expenditure)}
\]

B. **Total Investments**

I) Fixed Capital ______________

II) Working Capital _____________

**Total (I+II) ______________**

C. **Cost of Production (per Year)**

i) Total recurring expenditure (per year)

ii) Depreciation on building @5%

iii) Depreciation on machinery & equipments @10%

iv) Depreciation on fixtures/ Jigs./ Tools/ Moulds @25%

v) Depreciation on office equipments @20%

vi) Depreciation on furnaces@25%

vii) Interest on total investment @______________

(Actual to be charged by Financial Institutions or Banks)
D. **Total Cost of Production**

E. **Turnover Per Year**

<table>
<thead>
<tr>
<th>Sales</th>
<th>Qty.</th>
<th>Rate</th>
<th>Total</th>
</tr>
</thead>
</table>

F. **Net Profit Per Year**

(Before Taxes)

G. **Financial Assessments**

(E-D)

(i) Net profit Ratio: \[
\frac{\text{Profit (per year)} \times 100}{\text{Sales (per year)}}
\]

(ii) Rate of Return: \[
\frac{\text{Profit (per year)} \times 100}{\text{Total investment}}
\]

(iii) Break Even Point (BEP) Total Fixed Cost (FC) Per Year

(a) Depreciation
(b) Rent
(c) Interest on total Investment
(d) 40% of Salary & wages
(e) 40% of overheads
(f) Insurance

\[
\text{B.E.P.} = \frac{\text{FC} \times 100}{\text{FC} + \text{Profit}}
\]

H. **Name & Addresses of Suppliers:**

*Dr. Sanjaya Kumar Dash*

*Professor*
Sample project report for Production of Cereal flakes: Rice

Nature of product and applications
Rice flake is one of the many traditional products in India. The product is used as a common snack food in most parts of India. Many products can also be prepared from rice flakes. Flaked rice is suitable for preparation of soft cooked rice, deep fat fried products, such as toasted and seasoned mixture, energy/weaning food, etc.

Market potential
The price of different types of flaked rice depending on thickness is as follows:
Thin: Rs. 18/kg (Retail price)
Thick: Rs. 15/kg (Retail price)

Installed capacity
Suggested economic capacity : 1500 kg /shift/day
No of days of harvesting : 1 shift/day, 300 days/year
Capacity : 450 tonnes/ annum
Optimum capacity utilisation : 70%

Availability of raw material- Sources
The main raw material used for the manufacture of flaked rice is paddy. India produces over 100 million tonnes of paddy per annum. It should be well matured, clean, uniform in size, yellowish or brown in colour. Paddy should be free from insect infestation and even extraneous materials. Paddy is dried to optimal level of 12-14% moisture content.
Raw material is readily available and there is no constraint for procuring. Any variety can be used; preferably bold varieties are used. The units can be installed in paddy growing areas.

Production Statistics

Technology / Manufacturing process
The unit operations involved in the process are: cleaning, soaking, roasting, shelling, polishing, flaking, sieving & drying.
The paddy is cleaned free from contaminants, soaked in hot water over night and roasted. The roasted paddy is shelled immediately, polished and flaked. The flaked rice is passed through shifter to separate the husk and bran powder and broken pieces and dried.

process flow chart
Availability of technology
The manufacturers have to take a license under FSSAI.

Plant and Machinery
Principal equipments:
Hot water soaking tanks (150kg/h or 300kg/h), Edge runner (60kg/h, 6 numbers)
Auxiliary equipments : Weighing scales, trollies, fumigation equipment
All equipments are indigenously available.

Plant and Machinery Suppliers / Manufacturers

Location- suitability
The major factor to be considered for location of the manufacturing unit is nearness to the availability of raw materials. The factors to be considered are infrastructural facilities and access to the channels of distribution network.

Manpower and utilities
Manpower : 20 nos.
Power : 25 kW
Water : 5,000 Lts / day
Coal/ LD oil : 125kg /30ltrs/day

Project cost – Fixed Cost – Working capital

<table>
<thead>
<tr>
<th>Cost component</th>
<th>Rs.'000</th>
</tr>
</thead>
<tbody>
<tr>
<td>a) Land and land development (500 sq.m.)</td>
<td>50.00</td>
</tr>
<tr>
<td>b) Building and civil construction (100 sq.m.)</td>
<td>485.00</td>
</tr>
<tr>
<td>c) Plant and Machinery</td>
<td>150.00</td>
</tr>
<tr>
<td>d) Miscellaneous fixed assets</td>
<td>50.00</td>
</tr>
<tr>
<td>e) Preoperative expenses</td>
<td>50.00</td>
</tr>
<tr>
<td>Total fixed capital</td>
<td>785.00</td>
</tr>
<tr>
<td>Working capital margin (25%)</td>
<td>89.00</td>
</tr>
<tr>
<td>Total project cost</td>
<td>874.00</td>
</tr>
<tr>
<td>Total working capital required at 18.5% of turnover</td>
<td>354.00</td>
</tr>
</tbody>
</table>

Means of finance

Promoter’s contribution 219.00
Term loan 655.00

Annual operating expenses
Any other special feature

During the manufacture of rice flakes many by-products like husk (22%), bran (5%), & broken flakes (2%) are obtained. The husk can be used for heating water required for soaking paddy & heating the grain roaster for roasting the soaked paddy. The bran, which is rich in oil (18-25%) & obtained during polishing is pure & stabilized. Hence FFA will not develop & the bran can be used to extract edible oil. The broken flakes can be used for preparation of traditional food products.
# Annexure 1 Processed product profile for different agricultural commodities

<table>
<thead>
<tr>
<th>Sl. No</th>
<th>Crop</th>
<th>Product range</th>
</tr>
</thead>
</table>
| 1      | Cereal | (a) Rice Parboiled, Raw, Puffed, Flour, Candy, Dosa and Idli mix  
(b) Wheat Rawa, Puffed wheat, Flaked wheat, Bread, Cakes, Extruded snacks, Pastries, Biscuits, Spaghetti, Vermicelli, Malt, Wheat germ and Vitamin E concentrate  
(c) Maize Flour, Semolina, Husk, Grits, Puffed corn, Flake, Corn oil, Starch  
(d) Ragi Flour, Weaning foods |
| 2      | Pulses | (a) Arhar Dhal, Weaning food, RTS foods  
(b) Mung Dhal, RTS snacks, Papad, Weaning food, Chikkies |
| 3      | Oil seeds | (a) Groundnut Edible oil, Oil cake for cattle feed, Shell for fuel  
(b) Sesamum Edible oil, Deoiled cakes, Chikkies  
(a) Mustard Edible oil, Deoiled cake  
(b) Sunflower Edible oil, Deoiled cake |

( Page 80 )
**Annexure 2 Basic information on some small scale post harvest Equipments**

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Equipment</th>
<th>Specification</th>
<th>Capacity (kg/h)</th>
<th>Power (hp)</th>
<th>Cost</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Cleaner-cum-grader</td>
<td>2.5&quot;X6’</td>
<td>100</td>
<td>1</td>
<td>25,000/-</td>
</tr>
<tr>
<td>2</td>
<td>Dal mill</td>
<td>18”</td>
<td>60</td>
<td>3</td>
<td>30,000/-</td>
</tr>
<tr>
<td>3</td>
<td>Chuda mill</td>
<td>36”</td>
<td>4 bag</td>
<td>10</td>
<td>50,000/-</td>
</tr>
<tr>
<td>4</td>
<td>Stone grinder- Horizontal</td>
<td>20”</td>
<td>100</td>
<td>10</td>
<td>15,000/- without motor</td>
</tr>
<tr>
<td>5</td>
<td>Stone grinder- Vertical</td>
<td>16”</td>
<td>100</td>
<td>10</td>
<td>14,000</td>
</tr>
<tr>
<td>6</td>
<td>Dry grinder</td>
<td>10”X5”</td>
<td>20-60</td>
<td>2</td>
<td>26,000/-</td>
</tr>
<tr>
<td>7</td>
<td>Wet grinder</td>
<td>5”</td>
<td>30</td>
<td>1</td>
<td>10,000/-</td>
</tr>
<tr>
<td>8</td>
<td>Grain dryer</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Tray dryer</td>
<td>6 tray</td>
<td>50</td>
<td></td>
<td>35,000/-</td>
</tr>
<tr>
<td>10</td>
<td>Papad machine</td>
<td>8</td>
<td>1</td>
<td></td>
<td>28,000/-</td>
</tr>
<tr>
<td>11</td>
<td>Hammer mill</td>
<td>8”</td>
<td>30</td>
<td>2</td>
<td>18,000/-</td>
</tr>
<tr>
<td>12</td>
<td>Roaster</td>
<td>42</td>
<td>100</td>
<td>2</td>
<td>90,000/-</td>
</tr>
<tr>
<td>13</td>
<td>Baby oil expeller</td>
<td>24 patti</td>
<td>45</td>
<td>5</td>
<td>45,000/-</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td>---</td>
<td></td>
</tr>
<tr>
<td>14</td>
<td>Mixer</td>
<td>25</td>
<td>2</td>
<td>25000/-</td>
<td></td>
</tr>
<tr>
<td>15</td>
<td>Destoner</td>
<td>20X32</td>
<td>200-300</td>
<td>3</td>
<td>65000/-</td>
</tr>
<tr>
<td>16</td>
<td>Band sealer</td>
<td></td>
<td></td>
<td>25000/-</td>
<td></td>
</tr>
<tr>
<td>17</td>
<td>Bakery oven</td>
<td>6 tray</td>
<td>50-80</td>
<td>90000/-</td>
<td></td>
</tr>
<tr>
<td>18</td>
<td>Powder packing machine</td>
<td>50-200 g</td>
<td></td>
<td>140000/-</td>
<td></td>
</tr>
<tr>
<td>19</td>
<td>Extruder</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
# Annexure 3 List of Rice mill manufacturers

<table>
<thead>
<tr>
<th></th>
<th>Manufacturer</th>
<th>Address</th>
<th>Contact Details</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>RICETEC Machinery Pvt. Ltd., #57/P, Phase-1, I.D.A., Jeedimetla, Hyderabad- 500 055, Andhra Pradesh.</td>
<td>Ph: 040-23195938 E-mail: <a href="mailto:rice_tec@rediffmail.com">rice_tec@rediffmail.com</a></td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>Sri Venkateswara Engineerings, Mfrs.Modern Rice Mills &amp; Machinery, Nidamanuru-521104, Vijayawada, A.P., India</td>
<td>Ph: ( 0 ) 0866-2842771 Contact for Orissa-9866075985</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Sahara Milling Systems Pvt. Ltd., 9, Sardar Colony Main Road, Ekkaduthangal, Chennai-97, Tamilnadu, India</td>
<td>Ph: 0091-44-2225 2128, 093810 26729 E-mail: <a href="mailto:Riceland@vsnl.net">Riceland@vsnl.net</a></td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>Sunshine, 479, Bangalore Highway, Nazarathpet, Poonamallee, Chenai- 602 103</td>
<td>Ph: 044-26494855, 094440 25390 E-mail: <a href="mailto:sunshinebabu@yahoo.co.in">sunshinebabu@yahoo.co.in</a></td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>MILLTEC Machinery Pvt. Ltd., 51-A, 1st Phase, Bommasandra Industrial Area, Bangalore- 560 099</td>
<td>Ph: +91-80-7831128 Email: <a href="mailto:marketing@milltecmachinery.com">marketing@milltecmachinery.com</a></td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>G.G. Dandekar Machines Works Ltd., Dandekarwadi, Bhiwandi- 421 302 (Dist. Thane) Maharastra State</td>
<td>Ph: 02522-229870 E-mail: <a href="mailto:dandekar@bom2.vsnl.net.in">dandekar@bom2.vsnl.net.in</a></td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Suri Engineers Private Ltd., # 4/4. I.D.A., Nacharam, Hyderabad- 500 076, A.P., India</td>
<td>Ph. 040-27150282, 27177726 Fax- 040-27172741 E-mail: <a href="mailto:info@suriengineers.com">info@suriengineers.com</a></td>
<td></td>
</tr>
<tr>
<td>8</td>
<td>Buhler ( India ) Pvt. Ltd. 13-D, KIADB Industrial Area Attibele, Bangalore- 562 107, India</td>
<td>Tel. +918022890000 <a href="http://www.buhlergroup.com">www.buhlergroup.com</a></td>
<td></td>
</tr>
</tbody>
</table>
### Annexure 4 List of manufacturers for different processing equipments

<table>
<thead>
<tr>
<th>Manufacturer’s address</th>
<th>Machines</th>
</tr>
</thead>
<tbody>
<tr>
<td>Buhler ( India ) Pvt. Ltd. 13-D, KIADB Industrial Area Attibele, Bangalore- 562 107, India Tel. +918022890000 <a href="http://www.buhlergroup.com">www.buhlergroup.com</a></td>
<td>Rice Processing machines</td>
</tr>
<tr>
<td>Jas Enterprises,60, Shreenathji estate, Panna estate Road, Soni’s chawl, Rakhial, Ahmedabad, Gujrat,India 380 023 Ph. +91-79-22743454 E-mail : <a href="mailto:info@jasenterprize.com">info@jasenterprize.com</a></td>
<td>Mini Dal Mill Chapati machine (Semi automatic )</td>
</tr>
<tr>
<td>Forsberg Agritech ( I ) Pvt. Ltd., 123,GIDC Estate Makapura, Vadodara-390 010 Ph. 0265- 2645752 E-mail : forsagri@ wilnetonline.net</td>
<td>Hullers- Impact Huller and Huller Scarifier, Primary processing equipments</td>
</tr>
<tr>
<td>EMMMPPE Associates, 2/368-A, Irugur Road, Chinniampalayam, Coimbatore – 641 062, Tamilnadu, India Ph : (091 422) 2629177 e-mail : <a href="mailto:info@emmppe.com">info@emmppe.com</a></td>
<td>Colour Sorter ( NT PUBU Series )</td>
</tr>
<tr>
<td>Tinytech Plants Address: Tagore Road, Rajkot, Gujarat - 360 002, India Phone: +(91)-(281)-2480166 Fax: +(91)-(281)-2467552 Website: <a href="http://www.indiamart.com/tinytechplants/">http://www.indiamart.com/tinytechplants/</a> Send Trade Enquiry Now</td>
<td>Oil expellers, popcorn maker, industrial boilers and</td>
</tr>
<tr>
<td>Rajkumar Agro Engineers Pvt. Ltd. Address: Near Union Bank, Ghat Road, Nagpur, Maharashtra - 440 001, India Phone: +(91)-(712)-2725271 Website: <a href="http://www.indiamart.com/oilexpeller/oil-expellers-mini.html">http://www.indiamart.com/oilexpeller/oil-expellers-mini.html</a></td>
<td>Oil expellers, hand operated oil expeller, 3 hp single oil expeller, three phase table model oil expeller, 4 bolt expeller, 4 bolt export model oil expeller and 6 bolt oil expeller.</td>
</tr>
<tr>
<td>Company Name</td>
<td>Address</td>
</tr>
<tr>
<td>--------------</td>
<td>---------</td>
</tr>
<tr>
<td>Bharat Heavy Machines</td>
<td>123/280, Sick Line Factory Area, Fazalganj, Kanpur, Uttar Pradesh - 208 012, India</td>
</tr>
<tr>
<td>Company Name</td>
<td>Address</td>
</tr>
<tr>
<td>--------------------------------------------------</td>
<td>--------------------------------------------------------------------------</td>
</tr>
<tr>
<td>Goldin (India) Equipment Private Limited</td>
<td>F-29, B.I.D.C Estate, Gorwa, Vadodara - 390 016, India</td>
</tr>
<tr>
<td>Able Manufacturers</td>
<td>12-2-799/2, g - 2, Jandar Nagar, Mehdipatnam, Hyderabad - 500 028, India</td>
</tr>
<tr>
<td>Labh Machineries-A Unit of Labh Group Of Companies(Water Plant Division)</td>
<td>403-405 Time Square, Near Pariseema Complex C. G. Road, Ahmedabad - 380 006, India</td>
</tr>
<tr>
<td>Index Engineering Company, Indore</td>
<td>13/2, Chhoti Gwal Toli, Shop no. 13 , Ashian Tower, Near Sarwate Bus Stand, Indore - 452 001, India</td>
</tr>
<tr>
<td>AVITY AGROTECH AND INDUSTRIES</td>
<td>123, GIDC ESTATE, MAKARPURA, Vadodara-390010</td>
</tr>
<tr>
<td>Address</td>
<td>Phone Numbers</td>
</tr>
<tr>
<td>----------------------------------------------</td>
<td>--------------------------------</td>
</tr>
<tr>
<td>Orissa Machinery and Mill Store, Jatni, Mob: 9437232887</td>
<td></td>
</tr>
<tr>
<td>Mill and Machinery store, Buxibazar, Cuttack, Mob: 9861170010</td>
<td></td>
</tr>
<tr>
<td>S.K. Engineering &amp; Allied Works, Bahraich - UP Tel :- +91-5252-232964, 233211, 233294, 232555 Email :- <a href="mailto:skengg21@hotmail.com">skengg21@hotmail.com</a></td>
<td></td>
</tr>
</tbody>
</table>