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Postharvest operations and quality specifications for rice

A trainer's manual for smallholder farmers in Tanzania

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The *Enhancing partnership among Africa RISING, NAFAKA, and TUBORESHE CHAKULA Programs for fast tracking delivery and scaling of agricultural technologies in Tanzania* is an interdisciplinary and inter-institutional project that aims to address smallholder farmers' needs in the semi-arid and sub-humid zones of Tanzania. The 3-year project is funded by the USAID Mission in Tanzania as part of the U.S. Government's Feed the Future initiative.

Through participatory and on-farm approaches, candidate technologies are being identified and evaluated for scaling by the project team. This is being achieved through the already established networks by Tanzania Staples Value Chain (NAFAKA), Tuboreshe Chakula (TUBOCHA), and other institutional grassroots organizations, creating an opportunity for mainstreaming into wider rural development programs, beyond Africa RISING's current zones of influence.

The project is led by the International Institute of Tropical Agriculture (IITA) and the USAID Tanzania mission-funded programs NAFAKA and TUBOCHA. Developmental activities addressing the project objectives are being implemented in Manyara, Dodoma, Morogoro, Iringa, and Mbeya Regions in Tanzania.

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ACDI/VOCA	Agricultural Cooperative Development International / Volunteers in Overseas Cooperative Assistance
Africa RISING	Africa Research in Sustainable Intensification for the Next Generation
CGIAR	Consortium of International Agricultural Research Centers
FTF	Feed the Future
GDP	Gross Domestic Product
IITA	International Institute of Tropical Agriculture
USAID	United States Agency for International Development

Overview

Agriculture is the mainstay of Tanzania's economy. About 80% of the total population relies directly on agriculture as the primary food and income source. The sector contributes about 30% of the GDP, and provides employment to 65.5% of Tanzanians. A wide range of ecological conditions makes it possible to cultivate various types of crops across the 29 regions of the country. Rice is the second most cultivated food and commercial crop in Tanzania after maize. The total cultivated area is about 18% of the cultivated land and therefore the crop is a major source of food, employment and income for many households. A review of rice postharvest losses in some neighboring countries shows that quantitative postharvest losses of rice are between 5 to 26%. The losses include 7% during harvesting, 6% during threshing, 3% during drying, 2.5-5% during winnowing, 2-3% during transportation, 3.7% during storage, and 3.5% during milling. Such losses are not only counter-productive but strain efforts to feed the population as well as lift farmers out of poverty and improve their welfare.

This manual is intended to help extensionists and farmer advisors to deliver accurate knowledge on the management of harvested grain, so as to reduce postharvest losses, and improve quality and safety. It is expected that through use of this manual, farmers will be better able to take important decisions on choice and application of improved technologies to reduce postharvest food losses, and therefore improve food security at household and national level, earn employment and incomes, protect the environment and increase productivity without the need to employ extra production resources.

Scope

The content of this manual is intended for extensionists and farmer advisors who link directly with smallholder farmers, and the target is to address knowledge and technology-use gaps. The first part presents a general description of the rice post-harvest system. It identifies the various unit operations, gives an overview of the possible causes of losses, and points out the general measures that may be applied to mitigate those losses. The second part is a presentation of rice quality standards and specifications within the East African region, and elaborates approaches that small-scale farmers can apply to raise the quality of their produce to market standards. This second part of the manual is intended to guide extension officers, development practitioners and other agricultural advisors to offer training that will equip farmers and small traders with techniques of assessing the quality purposes of taking informed quality improvement decisions, that enable them to cut down costs associated with rejection due to poor quality and benefit from better prices by producing and trading in high quality products.

Part 1

Postharvest process of rice

The rice postharvest process comprises a set of operations which cover the period from harvesting through to consumption. Key operations include harvesting, drying, transportation, storage, and milling, (parboiling), and marketing (see figure 1). The harvesting step involves a number of sub-activities (shaded grey in figure 1).

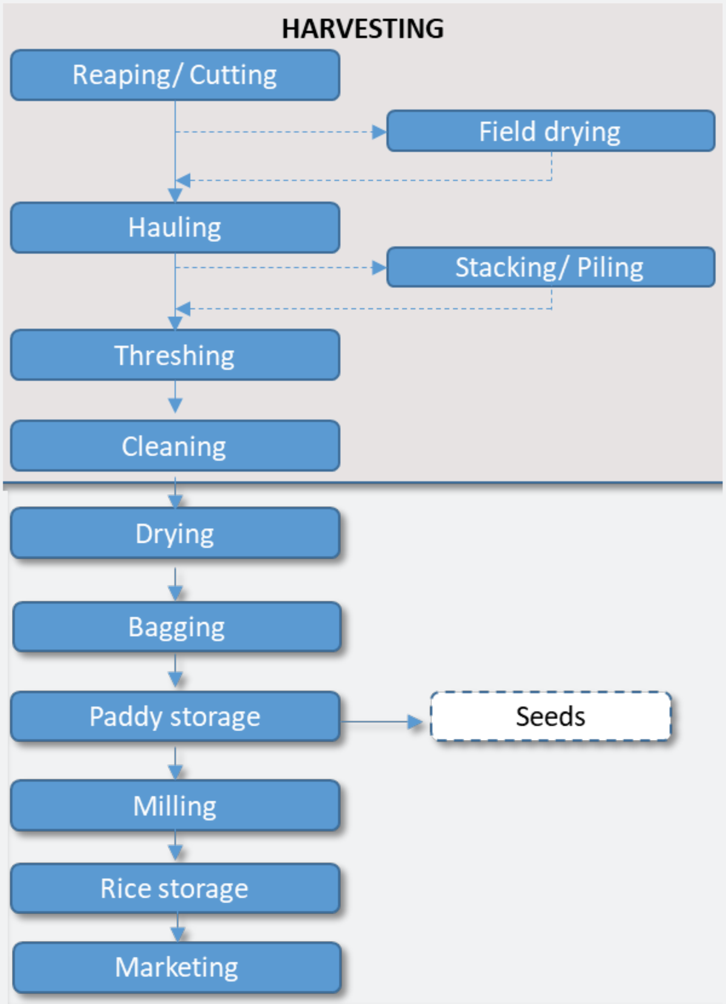


Figure 1. Typical postharvest processes for rice.

Harvesting

This is the process of collecting the mature rice crop from the field. Key activities include reaping, hauling, threshing, and cleaning to obtain paddy. These harvesting activities are achieved individually if done manually. It is important to apply good harvesting methods so as to maximize grain yield, and minimize grain damage and quality deterioration.

Step 1. Reaping – involves cutting the mature panicles or straw above ground. When done manually, a sickle or hand-held knife is used. A sickle is best for cutting 4-5 cm above ground level, while hand-held knives are best for cutting just below the panicle. Mechanical reapers can also be used but their use on lodged crop presents reaping difficulties. Small mechanical reapers are also available for use by farmers. These reduce the labor and time burden associated with harvesting. Some guidelines for proper reaping are presented in box 1.

Box 1. Guidelines for proper reaping

Proper timing is critical for quality.

- Do not harvest too early. A large percentage of unfilled or immature grains will lower yield and cause high grain breakage during milling.
- Do not harvest too late to avoid excessive losses caused by shattering and increased breakage.

Use any of the following indicators to know if crop is ready for reaping;

1. Moisture content: Grains should be firm but not brittle when squeezed between the teeth. Grain moisture at this stage is about 20 - 25%.
2. Number of ripe grains per panicle: Harvest when 80–85% of the grains have changed color to that of dry straw.
3. Number of days after sowing: About 130 - 136 days for late-maturing varieties, 113 - 125 days for medium maturing varieties, and 110 days for early-maturing varieties.
4. Number of days after emergence of panicle tip from leaf sheath: About 28–35 days in dry season harvesting or 32–38 days in the wet season.

Step 2. Threshing – during this process paddy grains are separated from the straw. Traditionally, manual methods (see figure 2) are used but these, while cheap, are associated with higher losses and low labor efficiency. Hand beating against stationary objects, and hand beating using sticks are some of the common manual threshing methods.

Figure 2. Common manual rice threshing methods. Photos credits: Retrieved from www.google.com.

Mechanical threshers

a) **Stationary threshers**

These comprise rotating drums fitted with peg-like prongs or rasp-bars (figure 3). The entire crop is fed into the thresher (feed-in thresher), or only the panicle is fed into the machine (hold-on thresher). The hold-on threshers are preferred in areas where rice straw is bundled and stored for later use. Mechanical threshers may be fitted with cleaning devices such as sieve and blower or fan to remove the chaff, that is, aid in winnowing.

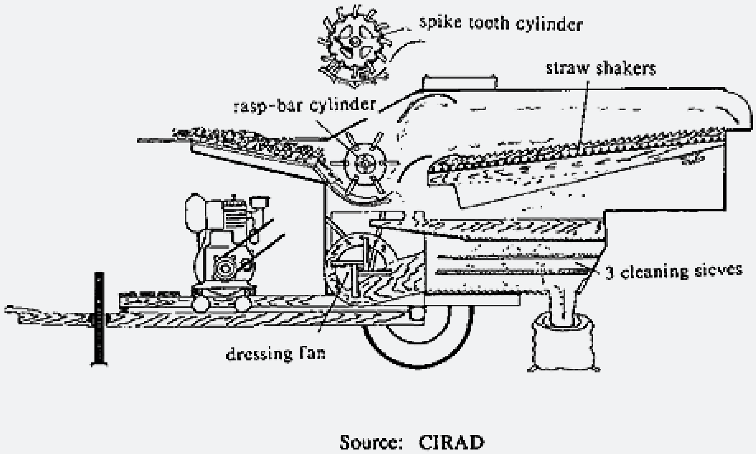


Figure 3. Stationary mechanical thresher. Source: IRRI.

b) **Axial-flow thresher**

The crop is loaded onto the feeding port from where it is scooped by the finger like pegs of the threshing cylinder into the space between the cylinder and the concave at one end of the machine (figure 4). As the threshing cylinder rotates, the pegs hit the material separating the grain from the straw. The threshed grain, and other small debris such as leaves and short pieces of straw fall through the oscillating screen where large impurities are separated. The units are usually mounted on a tractor or power tiller and can be moved from one point to another. These are suitable for commercial farmers or service providers.

Note: Field drying prior to threshining

In some cases, farmers leave the cut crop in the field for some time because they are either waiting for threshing services or because they want to pre-dry the paddy. In other cases, the crop is stacked in piles with the panicles inside to protect them from rain, birds and rodents. This practice can lead to massive heat build-up inside the stacks. As a result, molds grow quickly and infest the grains causing it to discolor within a few days. The relatively dry grains can also absorb water from the wetter straw which can lower milling quality. Usually, these field drying practices result in rice is of inferior quality hence should be avoided.

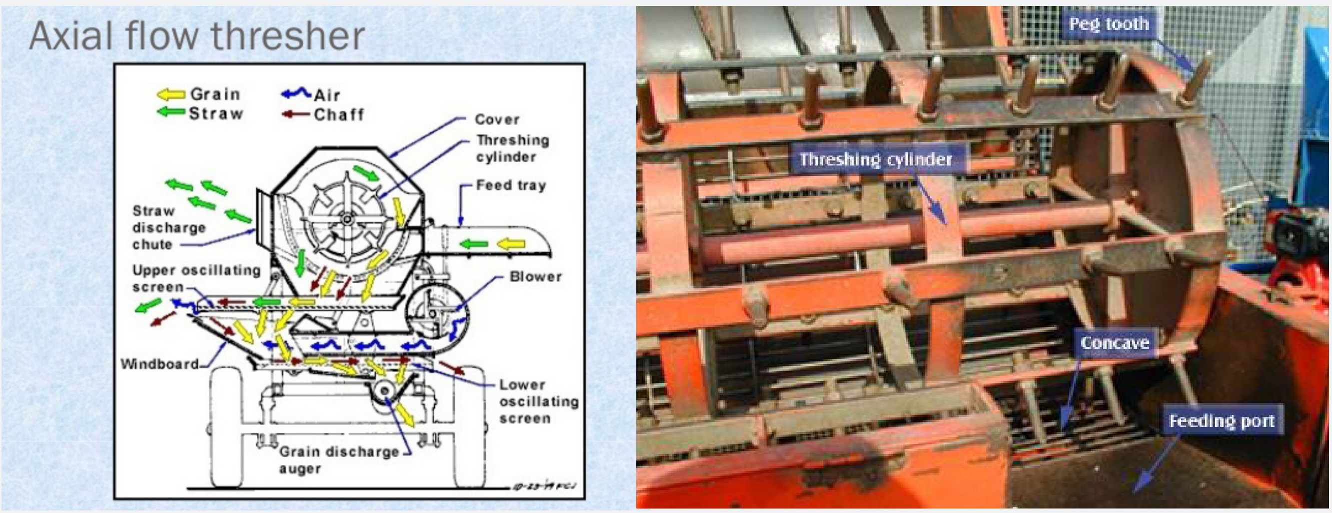


Figure 4. Axial flow thresher. Source: IRRI.

Step 3. Cleaning

In this operation the immature and unfilled grains, straw, chaff, weed seeds, soil, rubbish, and other non-grain materials are separated. Lighter materials such as unfilled grains, chaff, and straw are removed by winnowing (figure 5). Mechanical threshers have winnowers (see figure 3 &4). Heavier particles e.G. Stones and dirt that cannot be removed by winnowing are separated by sifting with the help of sieves or machine cleaners. Cleaning improves drying and storability of paddy. It also reduces dockage (impurities) at the time of milling, and improves milling output and quality.

Figure 5. Manual winnowing. Photo credit: IITA.

Box 2. Guidelines for proper threshing

1. The optimum moisture for threshing is 18-20%. To achieve this, the crop must be harvested at the optimum maturity stage (See Box 1).
2. Partial drying may be carried out by spreading in the field for a few days to make threshing easier. However, care must be taken not to over dry the crop to avoid excessive shattering.
3. Stacking or piling the crop in the field to dry is discouraged because it leads to rapid quality loss from discoloration and spoilage from molds, diseases, pests, and germination.

Drying

The moisture content of paddy at time of harvesting is about 20-25%. The threshed paddy should be dried as soon as possible to the critical moisture level depending on the foreseen period of storage (see table 1). So long as grain moisture is above 18%, the drying rate can be increased by increasing temperature of the drying air to 50 - 60 °c. Further drying from 18% to 14% moisture or below should be done slowly. During this period, the temperature of the paddy should not exceed 40°c. Low drying temperatures help preserve the rice aroma. Delayed, incomplete or improper drying lowers the quality. High moisture during storage causes discoloration due to heat damage, and encourages development of molds, bad odor, and insect pests. Drying of paddy is a sensitive process and should be well monitored to avoid overheating or rewetting.

Table 1. Recommended storage moisture content for paddy rice (source: IRRI).

Storage period	Moisture content
Weeks to a few months	14% or less
8–12 months	13% or less
Storage of farmer's seeds	12% or less
More than 1 year	9% or less

Sun-drying

Many small farmers in tanzania dry the sun. The paddy should be spread on mats or tarpaulins and attention is necessary to ensure no contamination with stones and dirt.

Box 3. Guidelines for proper sun-drying

- Winnow the paddy before drying.
- Dry the threshed paddy within 24 hours after reaping to avoid quality deterioration.
- Spread to a layer thickness of 2-4 cm to avoid heating-up (too thin layer) or moisture gradients (too thick layer) within the grain during drying.
- Turn the grain every 30 -60 minutes to achieve uniform moisture distribution.
- Dry to moisture content of 14% or below, depending on storage period.
- Ensure paddy is not subjected to rewetting during drying. Rewetting creates cracks that promote breakage during milling.
- Do not mix paddy of different moisture contents
- Monitor the temperature and moisture to prevent over-heating
- Protect the grain
- On hot days the grain temperature can rise significantly - the paddy should be covered to prevent over-heating.
- Cover the grain immediately in case of bad weather to avoid rewetting.
- Prevent contamination of grain and keep animals away.

Storage

Paddy stores better than milled rice because the husk provides some protection. The common storage systems for paddy are (a) bulk storage where the grain is stored unpackaged in granaries or containers such as woven baskets or wooden, metal, concrete, mud or plastic silos placed inside the house, and (b) bag storage where the produce is stored packaged in bags. Proper storage should prevent grain damage from bad weather, and storage pests – insects, rodents, and fungi.

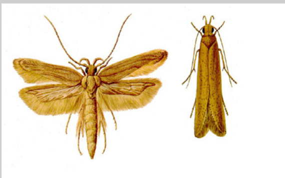
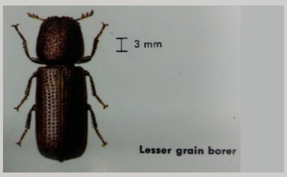
Insects

There are many insects that attack paddy and rice but only a few are major pests (see table 2). These include

a) Primary pests whose larvae feed from inside the grain: rice weevil, angoumois grain moth, and lesser grain borer.

b) Secondary pests that infest grain which has already been damaged by the primary pests: saw-toothed grain beetle and red flour beetle.

Table 2. Common insect pests that attack rice.

Pest	Charactersitics	
Rice weevil		Females lay a single egg in each grain after making a tiny hole on it. The egg develops in to larva, pupa, and then adult inside the grain. The life cycle takes 28-35 days when conditions are favorable. A single female can lay 150 eggs.
Angoumois grain moth		This insect infests the surface layer of bulk-stored grain, as adults are not able to penetrate deeply. Females lay eggs on the grain, which then hatch into larvae. The larvae bore into the grain and feed from inside leaving a thin layer of the outer seed coat intact. The adult emerges from the grain by pushing the thin layer of seed coat leaving a small trap door covering the exit hole on the kernel.
Lesser grain borer		Females lay eggs on the grain and hatch into larvae that enter the kernels or develop from inside by feeding externally on the flour-like dust that accumulates from feeding of the adults and other larvae. Large quantities of floury dust are produced. Females lay 300 – 500 eggs. The life cycle lasts 3-6 weeks in warm conditions.
Saw-toothed grain beetle		This insect is usually found as a secondary pest together with other insects but occasionally may be found alone as a primary pest. Eggs are laid singly or in small masses in a crevice in damaged grain. In flour eggs, are laid freely. Females lay about 150 eggs. The life cycle takes 3-10 weeks.
Rust-red flour beetle		This insect attacks milled products. Both adults and larvae feed only on the grain dust and broken kernels and do not attack the undamaged kernels. Infestation leads to objectionable odors. Females lay up to 500 eggs. The life cycle is 20 days under favorable conditions.

Measures to control insect infestation

Measure	Explanation
1. Carry out proper and timely and harvesting	✓ Reap at the correct stage of maturity and thresh immediately.
2. Ensure proper drying of paddy before storage	✓ Dry paddy to 14% moisture content or below. • Insects thrive best at 25-32°C and 70% relative humidity • The build-up of heat and humid conditions is minimized when paddy is dried to 14% moisture or below
3. Use clean storage containers, disinfect the store, and observe storage hygiene	✓ Do not store new and old grain together. ✓ Clean the store thoroughly before introducing new produce. • Remove and destroy old bags; • Clean and disinfest storage containers and equipment; • Clean store and disinfest store surfaces by spraying with Actellic (50 EC) according to manufacturer's instructions; • Examine reusable bags and where necessary treat with insecticide or dip in boiling water to kill any live insects and eggs.
4. Prevent infestation during the storage.	✓ Store grain as paddy because it is less susceptible to insect attack than milled rice. ✓ Ensure store has damp proof floor, water-proof walls, and intact roof ✓ Store in air-tight containers (Figure 6) • The containers also retain the original moisture, hence improve grain quality. • The cost is TZS 17,000 – 27,000 (US$ 7 – 12) per ton per year.  **Figure 6.** Different kinds of hermetic storage containers available for use by smallholder farmers in Tanzania. Photo credit: Christopher Mutungi/IITA.

Fungi

Fungi cause weight loss, loss of nutritive value, poor milling quality and deterioration in flavor and color of the rice. They also produce mycotoxins, e.G. Aflatoxins that are poisonous to humans. The contaminated produce cannot be consumed by humans and has no market. The extent of fungal contamination is influenced by grain moisture, temperature, condition of the grain such as physical damage, length of storage and insect activity during storage.

Box 4. The following actions will minimize damage by fungi

- Reap at the right stage of maturity, and thresh without delaying too long.
- Dry to safe moisture content (14% or below) after threshing.
- Clean paddy before storage to remove foreign matter, broken kernels, fines and other debris
- Clean storage structures thoroughly to remove dirt, dust, chaff, grain debris etc.
- Protect grain from insect damage. Insect activity will cause temperature and moisture content of the grain to rise, creating favorable conditions for fungi to growth.
- Check stored grain and aerate regularly.

Rodents

Rodent species associated with postharvest losses of grains in east africa are shown in figure 7.

The common African rat

The house mouse

The roof rat

Figure 7. Rodent species associated with postharvest losses of grains in east africa. The roof rat, and the mouse inhabit houses and storage structures whereas the common african rat is found in the fields but invades stores at the end of the harvest season when food in the field is scarce.

Rats and mice cause losses in a number of ways;
They feed on the stored produce; rats eat about 25 g of food per day, while mice eat approximately 3-4 g per day.

1. They contaminate the produce with urine, feaces, hairs and pathogens (figure 8). The contaminated batches are unfit for human consumption.
2. They damage storage materials and equipment e.g. Tarpaulins, bags, and to the store itself.
3. They transmit diseases to human beings e.g. Typhoid, paratyphoid, and scabies.

Figure 8. Rodent droppings on stored paddy. Photo credit: Christopher Mutungi/IITA.

Box 5. The following actions will minimize damage by rodents

- Granaries should be raised and fitted with rat guards.
- Ensure that doors, ventilation openings, and the junctions between the roof and the walls of granaries are well sealed.
- Keep the storage structure clean. Remove any spilt grain that may attracts rodents.
- Store bags in tidy stacks set up on pallets, ensuring that there is a space round the stack.
- Store any empty or old bags on pallets, and if possible, in separate stores.
- Keep store free of rubbish – hiding and nesting places for rodents.
- Clear area surrounding the store of tall weeds and stagnant water.
- Use rodenticides, mechanical traps and biological control (cat) to control rodents.

Milling

Traditional hand pounding using mortar and pestle

Pounding the paddy (see figure 9) creates friction between individual grains. The husk and bran layers are removed as grains rub against each other. The product is then cleaned by winnowing. The process is not efficient; there is large amount of broken rice, the procedure is labor intensive, and the out capacity is low.

Figure 9. Mortars used for pounding rice. Photo credit: Retrieved from en.clipdealer.com.

Single-pass single-stage mechanical mill

A steel friction type mill that uses high pressure is used to remove the hull and polish the grain at the same time (figure 10). However, grain breakage is high resulting in low head rice recovery, and the total milled rice recovery is also low. It is therefore only suitable for milling paddy for home consumption in villages where farmers don't have access to a custom rice mill.

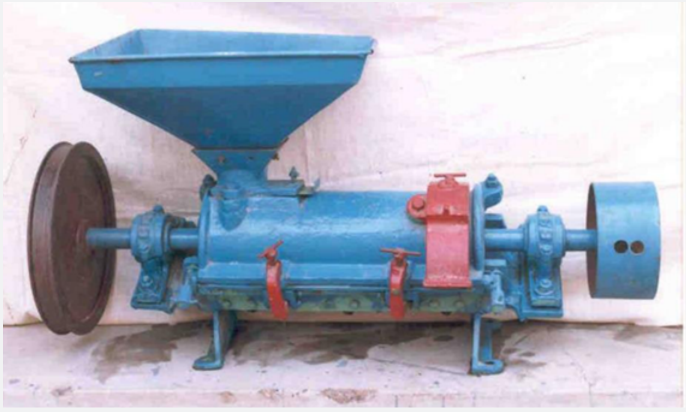


Figure 10. Single pass single stage mechanical mill. This is an improvement of the manual pounding method. Photo credit: Retrieved from www. google.com.

Two stage mechanical mills (single pass or two pass)

Two stage milling is either done in a compact 2-stage rice mill (figure 11), or with two separate machines, one for husking and another for polishing (figure 12). This mill achieves higher milling recovery than single-pass single-stage mill.

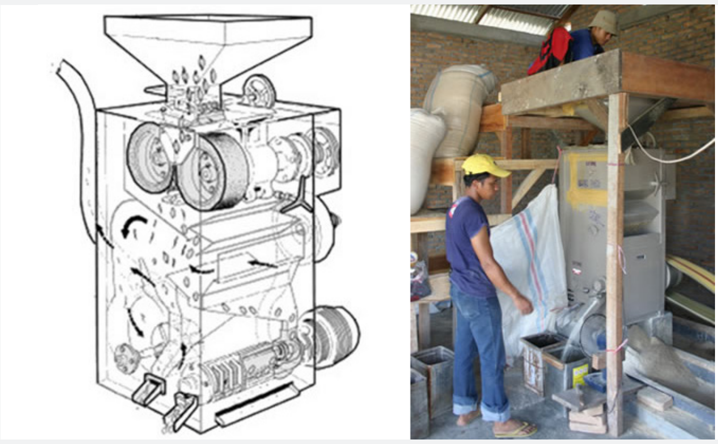
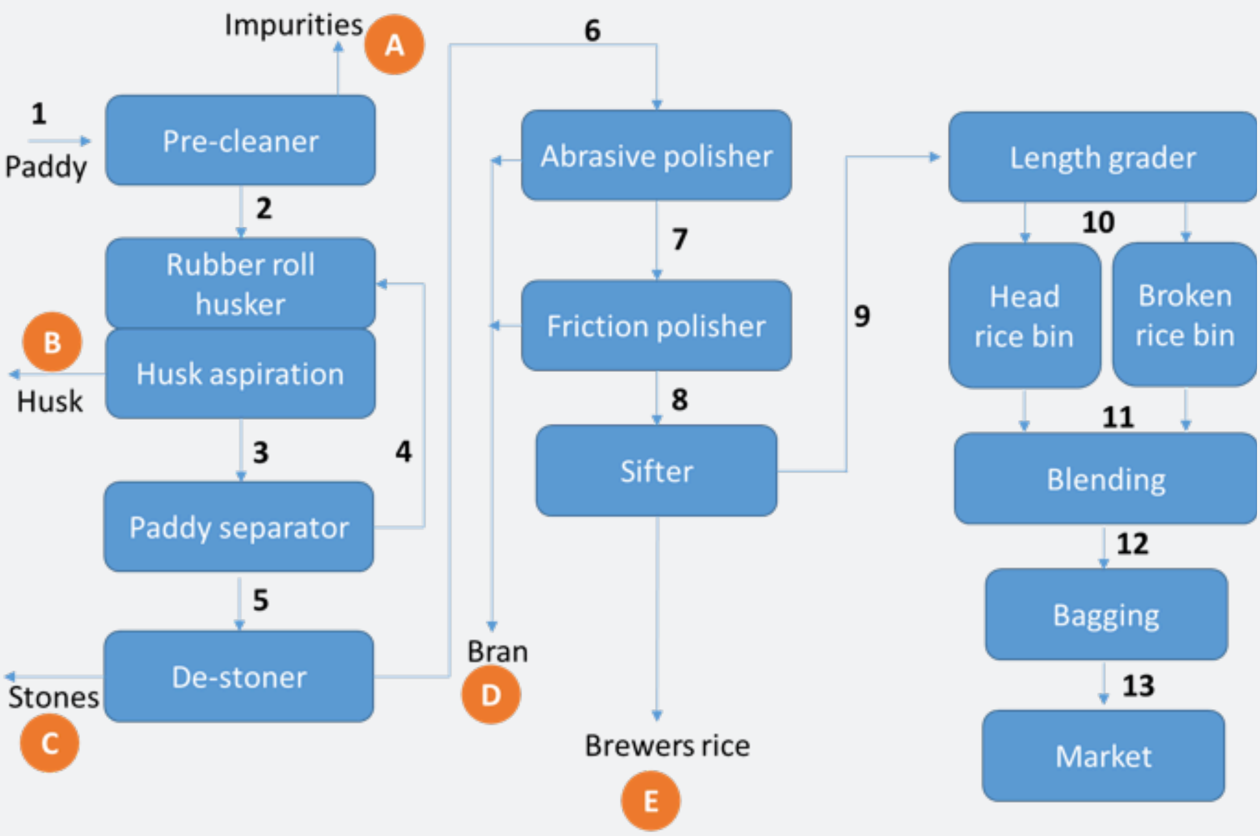


Figure 11. Schematic diagram (left) of compact rice mill with rubber rollers on top and steel polisher on the bottom. The rubber rollers remove the husk and the brown rice is then polished with steel friction-type whitener. Right; outside appearance of a diesel engine compact rice mill. Photo credit: Retrieved from www. google.com.

Figure 12. Two separate machines for two stage, two pass milling with rubber roller husker on the left and a steel polisher on the right. Photo credit: Retrieved from www. google.com.

Commercial milling

The milling process in commercial mills, also suitable for organized farmer groups (figure 13; figure 14), combines several operations in line so as to produce better quality and higher yields of milled rice. Key operations involved are presented in the table 3.



1	Paddy is fed into the intake pit feeding the pre-cleaner
A	Straw, chaff and empty grains are removed
2	Pre-cleaned paddy moves to the rubber roll husker:
B	Husk removed by the aspirator
3	Mixture of brown rice and unhusked paddy moves to the separator
4	Unhusked paddy is separated and returned to the rubber roll husker
5	Brown rice moves to the destoner
C	Small stones, mudd balls etc. removed by de-stoner
6	De-stoned, brown rice moves to the 1st stage (abrasive) whitener
7	Partially milled rice moves to the 2nd stage (friction) whitener
D	Coarse and fine bran removed from the rice during the whitening process
8	Milled rice moves to the sifter
E	Small brokens/brewer's rice removed by the sifter
9	Milled rice moves to length grader
10	Head rice separated into head rice and broken rice
11	Pre-selected amount of head rice and brokens move to blending station
12	Custom-grade milled rice moves to bagging station
13	Milled graded rice moves to the market

Figure 13. Flow diagram of a commercial rice mill. Adapted from IRRI.

Figure 14. A small scale commercial milling line that accomplishes pre-cleaning of paddy, de-husking, polishing, and sifting to produce white rice separated into head rice, large broken rice, small broken rice, and fine broken rice in Igulusi, Mbarali district Tanzania. Photo credit: Christopher Mutungi/IITA.

Table 3. Processes involved in commercial rice milling.

Process	Description
1. Pre-cleaning	✓ Foreign materials e.g. straw, weed seeds, soil, stones etc. are removed. This step improves de-husking efficiency and milling recovery. Four stages of separation are involved: • Scalping removes objects that are larger than the grain by passing the paddy on a flat vibrating screen or rotating drum screen; the grain and other smaller materials to pass through. • A second separator retains the paddy but allows broken grains, small stones and weed seeds to pass through. • A destoner separates stones that have same size as the paddy by virtue of their difference in specific gravity. • An air aspirator removes the dust and the light empty grains.
2. De-husking	✓ The husk layer is removed by passing the paddy between two abrasive surfaces that are moving at different speeds.
3. Paddy separation	✓ The output from the de-huller, which is a mixture of paddy rice, brown rice, husk, broken paddy, and bran is separated. • The husks, bran and very small broken rice are removed by aspiration. • The rest proceed to paddy separator where the paddy rice is separated from the brown rice on the basis of differences in specific gravity, buoyancy and size. The paddy is returned to the de-huller.
4. Polishing Process	✓ Brown rice is whitened by rubbing the grains against an abrasive surface to remove the bran.

5.	Sifting	✓ Polished white rice is separated into head rice, large broken rice, small broken rice and fine broken rice (brewer's rice) by a series of oscillating sieves. Head rice comprises kernels which are 75% or more the size a whole kernel. A good mill will produce 50-60% head rice, 5-10% large broken, and 10-15% small broken kernels.  **Figure 15.** Decreasing size of milled rice separated using a sifting process; head rice, large broken kernels, small broken kernels and fine broken kernels. Photo credit: Christopher Mutungi/IITA.
6.	Blending	✓ Depending on quality specifications for the targeted market, head rice is blended to achieve a predetermined amount of broken rice.
7.	Weighing and bagging	✓ The milled rice is weighed and packed in labeled bags, usually 50 kg sacks. ✓ Bags should be clean, sound, free from insects, and fungal infestation.

Box 6. Quality problems in milling

Under-milled rice

This is under-polished rice, or white rice with bran streaks left on it. Locally, consumers desire well-milled rice because of its better appearance. Under-milled rice may also not store well because of the high oil content of the bran.

Broken grains

Grain breakage is the result of cracks formed on the endosperm prior to milling. The cracks are caused by improper drying, rewetting of stored paddy, and inefficient milling methods. Medium or long grain varieties are more prone to breakage than short grain varieties.

Discoloration

The natural color of white rice can be affected during postharvest handling e.g. if wet paddy is left undried for long. The wet grain heats up and the grains turn yellow because of heat damage.

Chalkiness

The milled rice kernel is opaque rather than translucent. Chalkiness is caused by interruption during the final stages of grain filling, or by immature harvesting. Chalky grains are more brittle and break more readily during milling. Thus, whereas chalkiness disappears upon cooking and does not affect taste or aroma, it downgrades the quality of milled rice.

Damaged kernels

These are grains that are fully or partially darkened as a result of insect, mold or heat damage. The presence of even a few damaged grain kernels can severely downgrade rice.

Impurities

Impurities in milled rice suggest that the paddy was not properly cleaned prior to milling, or the milled rice was contaminated after milling.

Part 2

Grain quality

Grain quality means different things to different people depending on what they prefer. Thus, rice quality can be a combination of many factors such as smell (aroma), size, cooking characteristics, color, nutritional value, percent whole grains, etc.

Why quality is important

Consumer preferences (e.g. For a certain smell, whiteness or completeness of grain) affect what people buy and the market price.

How to maintain grain quality

Grain moisture content is the most important factor to manage in maintaining grain quality. The quality cannot be improved after harvest with the possible exception that parboiling may reduce grain cracking. From the point of harvest, the rate of grain deterioration may be reduced but not stopped. It is therefore important to have a uniform harvest on time, and then have a proper system of post-harvest management that will slow grain quality deterioration. Both good crop and post-harvest management are needed to maintain quality, increase prices and reduce losses.

Table 4. Key considerations to maintain quality (source: IRRI).

Factor	What to do
Variety	Grow varieties that meet market quality demands.
Crop management	Manage your field so that the crop matures uniformly. Good crop establishment, land leveling and uniform water, nutrient and pest management are important for uniform maturing of the crop. Uniformity of maturing is important as the moisture from the harvested less-mature grains can move to the dryer grains and cause grain cracking.
Harvest	Harvest grain at 20-25% moisture. Too wet or too dry leads to grain damage on threshing.
Stacking	Briefly stack harvested rice. If the crop has high moisture and temperatures are high, then rapid yellowing of the grain - even within 24hrs - can occur.
Threshing	Thresh promptly but at the right moisture. Too dry (less than 20%), grain will be broken during mechanical threshing leading to a lower percent of head rice. Too wet (more 25%), grain can be deformed during mechanical threshing. Manual threshing leads to less grain breakage, but can be very slow and other quality losses (e.g. fungal growth) can occur if not threshed and dried quickly.
Drying	Dry grain as quickly as possible to less 14% for medium term storage.
Grain storage	Do not mix wet grain and dry grain less than 16%. Moisture moves from the wet to the dry and this causes the dry grains to crack.
Milling	Mill rice at 12-14% moisture content to reduce cracking.

Rice quality standards and specifications

The majority of small holder rice farmers in tanzania produce paddy for sale to traders or millers who then produce milled rice for the market. To be able to produce high quality milled rice that is competitive in the market, it is important to begin with good quality paddy: right moisture content (14%); uniform maturity; uniform size and shape; free from cracks and mold damage; free from insect damage and free of contaminants and impurities. Production of good quality paddy requires timely and proper harvesting, threshing, drying, and storage. Untimely harvesting, improper drying, and poor storage contribute to broken and discolored milled rice. Mixing different rice varieties during post-harvest operations and contamination with impurities lowers the quality. Unclean paddy increases the time taken to clean and process the grain, reduces milling recoveries and quality of rice, and increases the wear and tear on milling machinery.

The benefits of accepting to use quality standards include:

- ✓ Increased transparency in trade. Standards formalize the language of trade, and therefore protect farmers, traders, processors and consumers from exploitation.
- ✓ Increased efficiencies that reduce costs, increase competitiveness and create incentives.
    - Farmers who meet quality specifications can get higher prices and long-term contracts from buyers, which in turn gives them incentive to invest more in production.
    - Processors who buy good quality produce are able to eliminate additional costly processing steps, and are therefore able to access better markets for their products by offering competitive prices.

The knowledge and implementation of quality standards has following positive impacts:

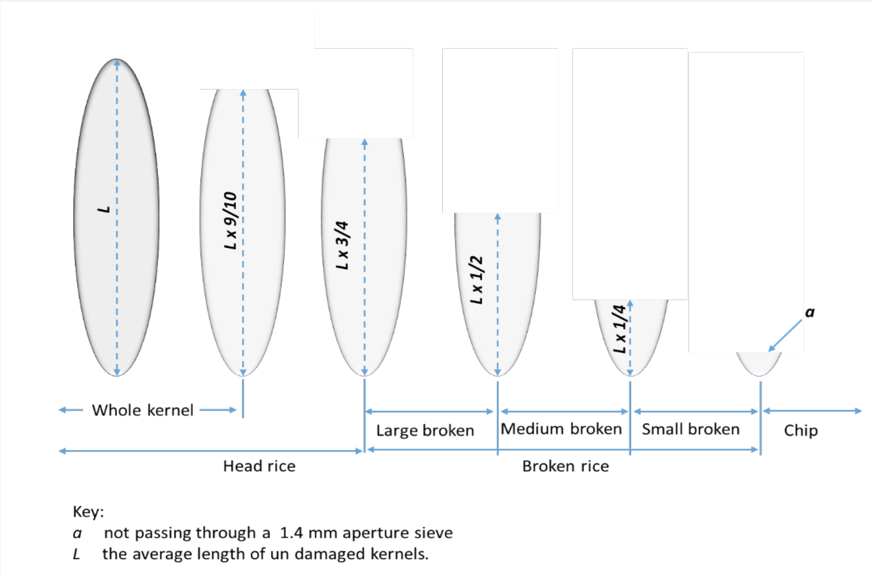
- Enhanced food safety by ensuring agreed limits for contaminants are adhered to;
- Improved nutritional value of products by safeguarding overall produce quality;
- Improved trade as producers and buyers can transparently determine the true value of produce;
- Increased productivity because farmers have the incentive to adopt technologies that enable them to produce more.

Table 5. Rice quality parameters.

Parameter	Definition	Appearance
1. **Moisture**	Should be below 14%	
2. **Live insects**	Weevils, moths, mites etc.	
3. **Organic matter**	Foreign matter of palnt origin e.g. leaves, seeds, stalks, chuff etc.	
4. **Inorganic matter**	Plastics, pieces of glass or metal, gravel/ stones, sand etc.	

5. **Paddy**	Rice grains with more than 12.5% hull cover on kernel surface.	
7. **Heat-damaged grains**	Rice grains discloloured by heat during storage.	
8. **Damage kernels**	Kernels with ground, weather, germ and mould damage, smut or other stains.	
9. **Shriveled kernels**	Immature, unripe or under developed kernels.	
10. **Chalky kernels**	Grains with floury, opaque appearance.	
11. **Contrasting varieties**	Red, brown, black or other coloured kernels apart from the dominant colour.	
12. **Red or red streaked**	Grains with brown or red streaks of bran on the surface of milled white rice (underpolished rice).	

13. **Filth**	Impurities of animal origin e.g. dead insects, insect fragments, larvae, pupae, mites, ants, hairs, feces, feathers etc.	
14. **Broken grains**	Pieces of rice that are less than ¼ of the average length of a whole kernel (see the cell below).	



Determination of rice quality parameters

Table 6. Sampling and testing equipment.

1. Sampling probe 	2. Sample divider 
3. Weighing balance 	4. Sieves (1.4 mm aperture size) 
5. Moisture tester 	6. Calipers 

Obtaining the primary sample

- Sampling should be done randomly so that every grain has an equal chance of being picked.
- Usually, a sampling probe (also called sampling spear) is used (see figure 15 and figure 16).
- Typical probes are cylindrical in shape. They are 40 – 45 cm long with a diameter of 2.5 Cm and a tapered end.

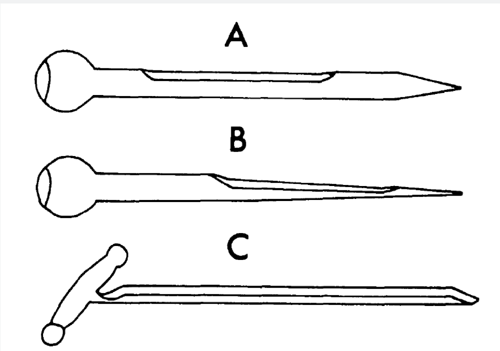
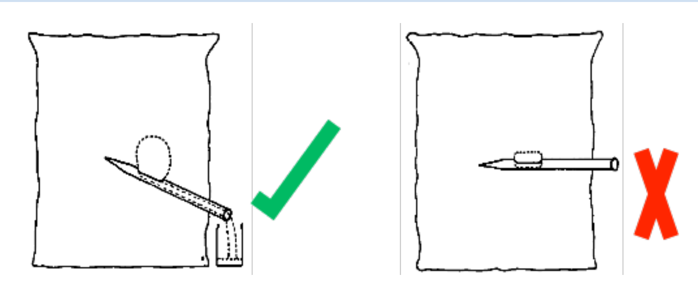
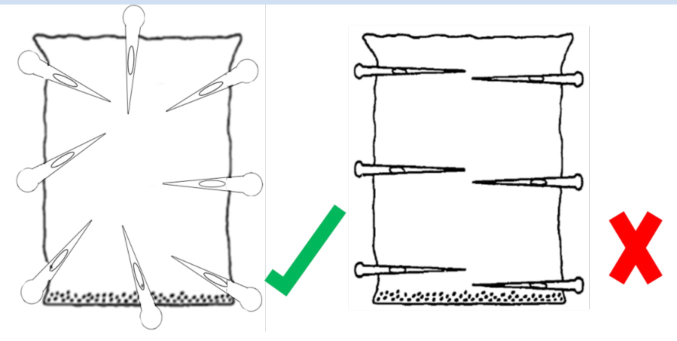


Figure 16. Different designs of probes used for obtaining sample from the sides of an ordinary bag.

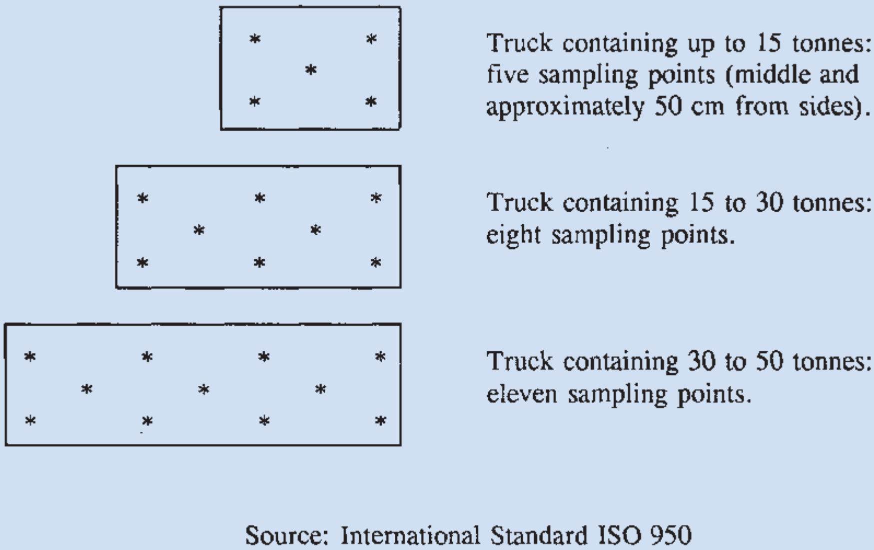
Note: these should not be used on hermetic bags.

Figure 17. A sampling probe for obtaining sample from bulk storage container e.g. From a metal silo.

Table 7. How sampling should be done in different situations.

<table>
<tr><th>Situation</th><th>Method of sampling</th></tr>
<tr><td>Sampling from an ordinary bag</td><td>The sampling probe should be inserted from a corner diagonally.
1. Push the probe into the bag to the required distance, with the open side facing downwards, and at an angle.
2. Twist the probe so that the open side is turned upwards in order to collect grain into the channel.
3. On withdrawing the probe from the bag, the grain is tipped out into a container

4. Repeat the sampling at least 6 times from different points of the same bag from all four directions so as to obtain a representative sample. Note that a representative sample may not be obtained if sampling is not properly done; e.g. in the illustration below, insects at the bottom of the bag will not be detected if sampling is not done from all sides of the bag.
</td></tr>
</table>

Sampling from a stack of bags	• If the stack is 10 bags or less, all bags should be sampled. • If the stack is 10 -100 bags, 10 randomly selected bags should be sampled.
Sampling from a truck	• When sampling from a track the scheme shown below should be used



Obtaining the test sample

1. Put all the samples taken from the different bags or points of the bag into one container.
2. Mix thoroughly, and then subdivide to obtain the final sample required for analysis.
   - A sample divider like the one shown below is used to subdivide that sample.

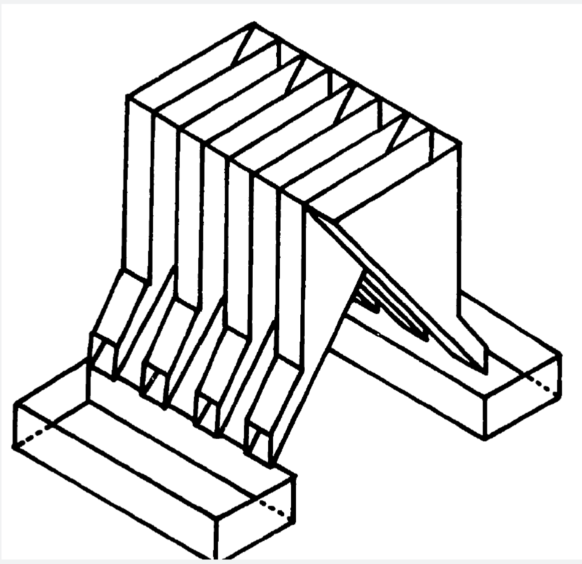


Figure 18. Box sample divider.

- If a sample divider is not available, use the "quartering method". Empty the sample on a flat surface to form a cone, and then subdivide as shown below.

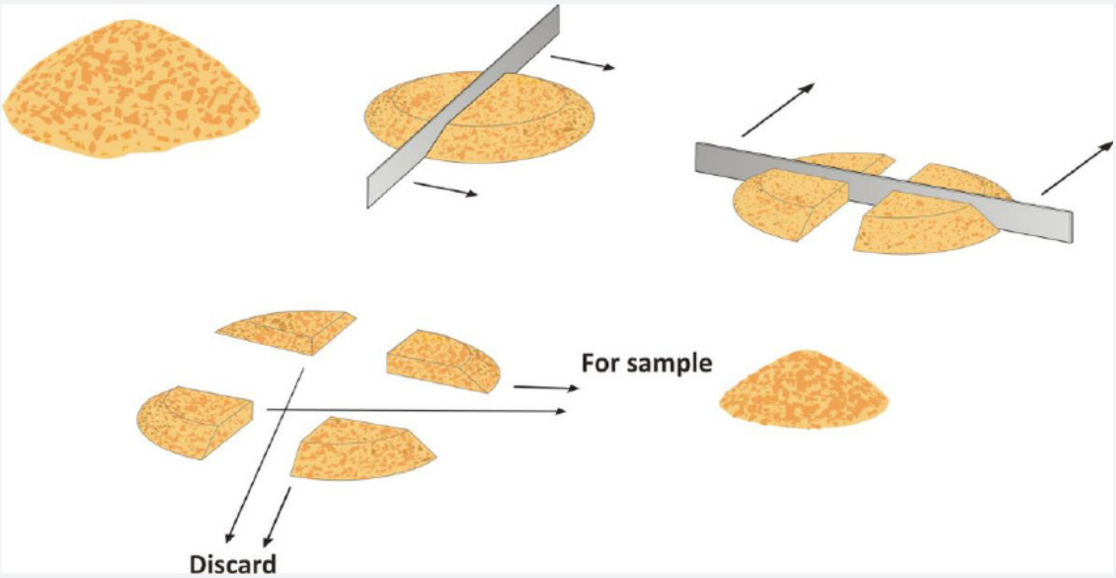
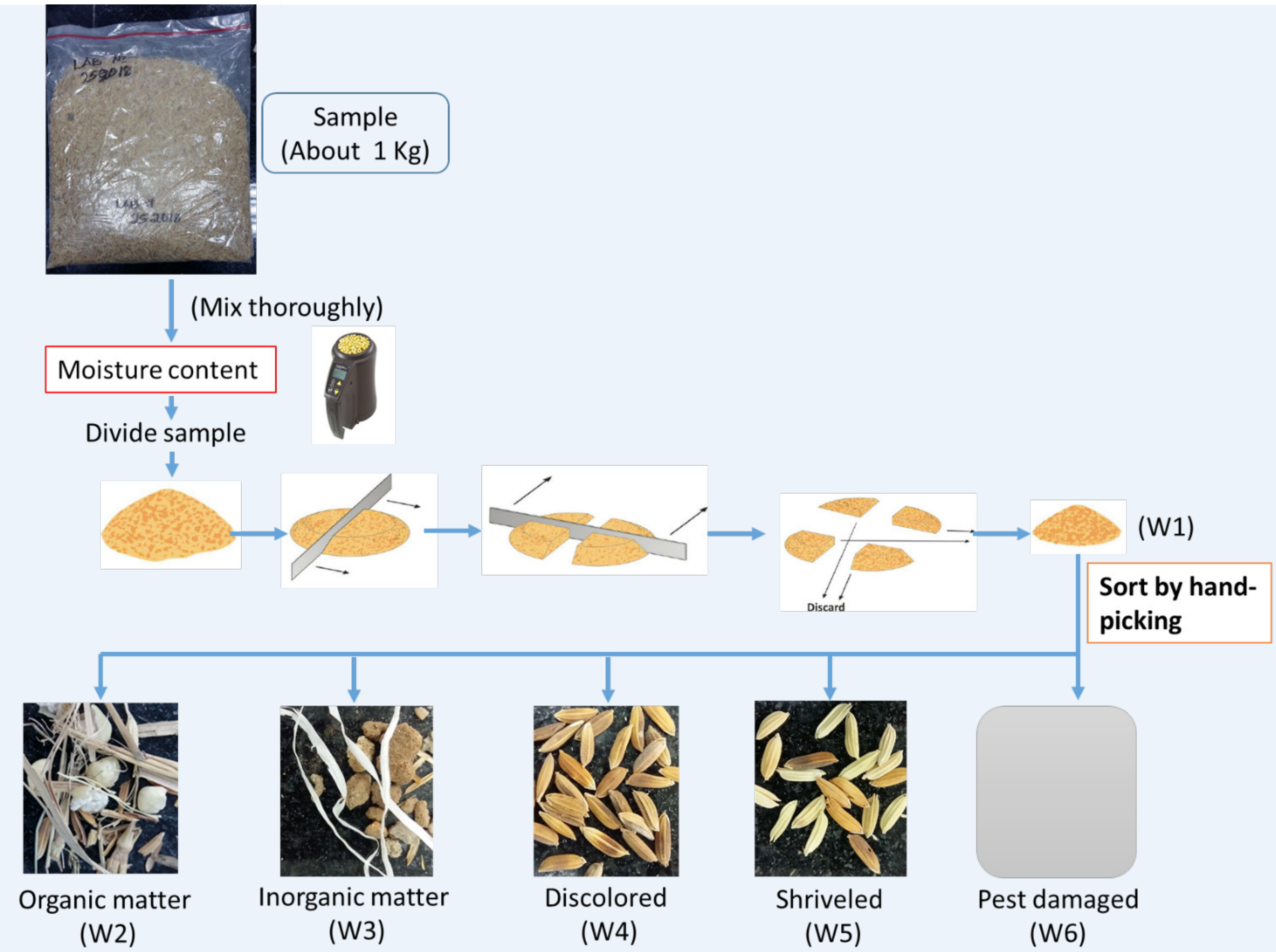


Figure 19. Sample quartering procedure.

Assessing the quality of paddy

Table 8. Steps for assessing various quality parameters in threshed paddy.

Foreign odor	Take a random sample in the hand and smell. The grain should not have unusual smell e.g. smell of pesticides, diesel, molds, or soil etc.



Organic matter (%)	Pick all foreign matter of plant origin e.g. leaves, seeds, stalks, straw, chuff etc. and weigh these together (W2). Calculate percentage organic matter as: (W2/W1) x 100.
Inorganic matter (%)	Pick any metallic pieces, stones, plastics, glass, sand, etc. and weigh these together (W3). Calculate the percentage inorganic matter as: (W3/W1) x 100.
Moldy/ discolored grains (%)	Pick all moldy and discolored paddy grains and weigh together (W4). Calculate the percentage moldy/ discolored grain as: (W4/W1) x 100.
Immature/ shriveled grains (%)	Pick all the shriveled/ unfilled or under developed paddy grains and weigh (W5). Calculate the percentage shriveled grains as: (W5/W1) x 100.
Pest damaged grains (%)	Pick all insect and rodent damaged grains and weigh (W6). Calculate the percentage inorganic matter as: (W6/W1) x 100.
Total aflatoxin	Send a sample to a specialized laboratory for testing.
Aflatoxin B1	Send a sample to a specialized laboratory for testing.
Fumonisin	Send a sample to a specialized laboratory for testing.

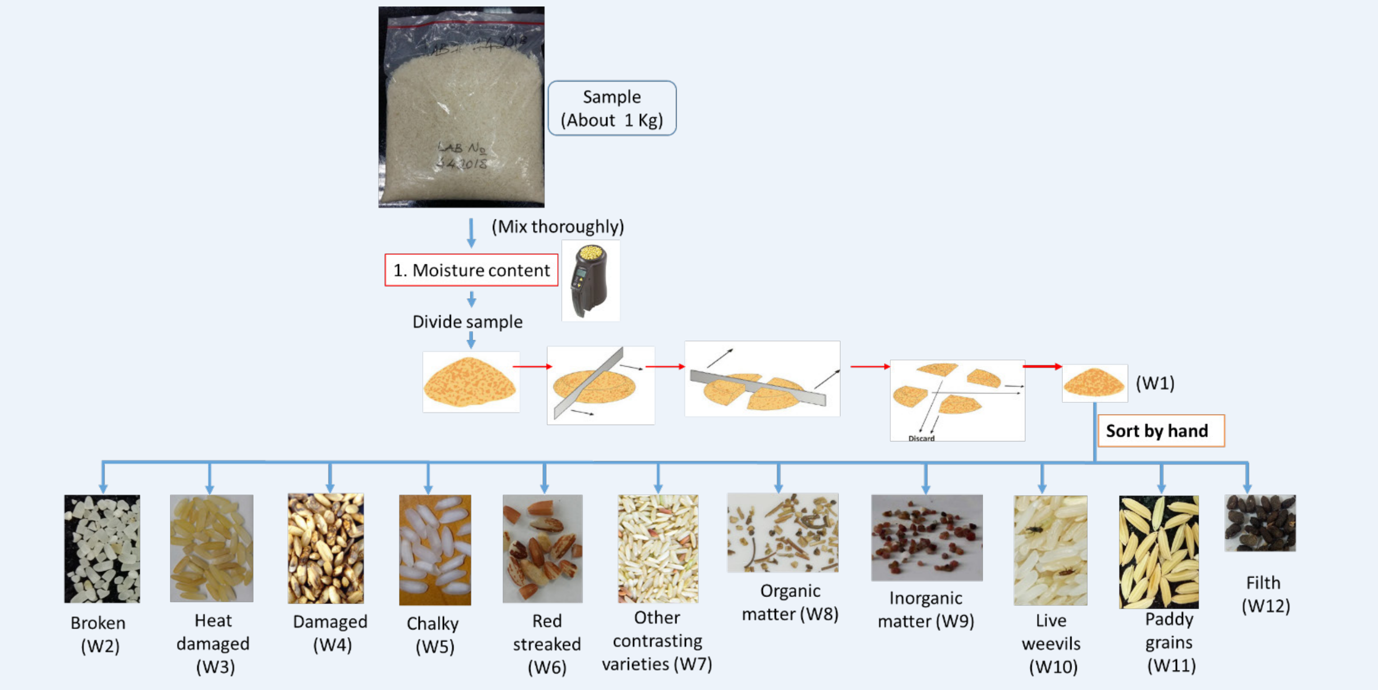
Table 9. East african quality specifications for paddy rice (source: eas 764:2011).

Quality parameter	**Maximum limits**		
	Grade 1	Grade 2	Grade 3
Moisture (%)	13	13	13
Organic matter (%)	1	1.5	2.0
Inorganic matter (%)	0.25	0.25	0.5
Pest damaged grains (%)	0.5	0.75	1.0
Discolored grains (%)	0.1	0.5	1
Immature/shriveled grains (%)	1	3	5
Total Aflatoxin (ppb)	10		
Aflatoxin B1 (ppb)	5		
Fumonisin (ppm)	2		

- Broken % in milled rice: is used to evaluate the paddy grades.
- Ungraded: paddy rice which does not fall within the requirements of grades 1, 2, and 3 but is not rejected.
- Reject grade: paddy which has objectionable odor, color, live insects or which does not possess the quality characteristics specified above.

Assessing the quality of white milled rice

Table 10. Steps for assessing different quality parameters in milled rice.



Foreign odor	Take a random sample in the hand and smell. The grain should not have unusual smell e.g. smell of pesticides, diesel, molds, or soil etc.
Broken (%)	Take a sub-sample (W1) and spread out the grains retained on the sieve on a black sheet of paper. Separate all grains whose length is less than ¾ of the average length of a full grain and weigh (W2). Calculate the percentage broken grains as: (W3/W1) x 100.
Heat damaged (%)	Pick all the heat damaged grains (discolored by heat during storage) and weigh (W3). Calculate the percentage heat damaged grains as: (W3/W1) x 100.
Damaged rice (%)	Pick all moldy, discolored paddy grains and pest damaged grains and weigh together (W4). Calculate the percentage moldy/ discolored grain as: (W4/W1) x 100.
Chalky (%)	Pick all grains with floury, opaque appearance and weigh togehther (W5). Calculate the percentage chalky grains as: (W5/W1) x 100.
Red or red streaked (%)	Pick all brown or red-streaked grains on milled white rice and weigh (W6). Calculate the percentage streaked grains as: (W6/W1)) x 100.
Other contrasting varieties (%)	Pick the contrasting variety grains (red, brown, black or other coloured kernels apart from the dominant colour) and weigh (W7). Calculate the percentage contrasting varieties: (W7/W1) x 100.
Organic (%)	Pick all foreign matter of plant origin e.g. leaves, seeds, stalks, straw, chuff etc. and weigh these together (W8). Calculate percentage organic matter as: (W8/W1) x 100.
Inorganic matter (%)	Pick any metallic pieces, stones, plastics, glass, sand, etc. and weigh these together (W9). Calculate the percentage inorganic matter as: (W9/W1) x 100.
Live weevils (number per kg)	Take a sample of 100 g, and spread on a white sheet of paper. Count the number of living insects, Multiply by 10 to report as number of insects/kg.
Paddy grains (%)	Pick the grains with more than 10% hull cover on kernel surface, and weigh (W11). Calculate the percentage inorganic matter as: (W11/W1) x 100.
Filth (%)	Pick all impurities of animal origin e.g. dead insects, insect fragments, larvae, pupae, mites, ants, hairs, droppings and weigh together (W12). Calculate the percent amount of filth as: (W12/W1) x 100.

Table 11. East africa quality specifications for white milled rice (source: east african standard 128:2013).

Quality parameter	**Maximum limits**		
	Grade 1	Grade 2	Grade 3
Moisture (%)	14	14	14
Broken, (%)	5	15	25
Heat damaged rice (%)	1	1.5	2.0
Damaged rice (%)	1.5	2.0	3
Chalky (%)	2	4	10
Red or red streaked (%)	2	6	12
Immature grains (%)	1	1.5	2
Other contrasting varieties (%)	1	2	3
Organic matters (%)	0.1	0.2	0.5
Inorganic matters (%)	0.1		
Live weevils (number per kg)	0		
Filth (%)	0.1		
Paddy grains (%)	0.3		
Total aflatoxin (ppb)	10		
Aflatoxin B1 (ppb)	5		
Fumonisin (ppm)	2		

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