Rice Quality

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Rice Quality- an overview

This skills section examines the different factors that affect grain quality, and explains how to measure grain quality characteristics for both paddy and milled rice.

Quality of rice is not always easy to define as it depends on the consumer and the intended end use for the grain. All consumers want the best quality that they can afford. As countries reach self-sufficiency in rice production, the demand by the consumer for better quality rice has increased. Traditionally, plant breeders concentrated on breeding for high yields and pest resistance. Recently the trend has changed to incorporate preferred quality characteristics that increase the total economic value of rice. Grain quality is not just dependent on the variety of rice, but quality also depends on the crop production environment, harvesting, processing and milling systems.

The quality characteristics of paddy and milled rice can be considered separately.

Quality characteristics of paddy

A number of interrelated features determine the quality of paddy. These are:

- Moisture content of paddy,
- Purity degree,
- Varietal purity,
- Cracked grains,
- Immature grains,
- Discolored/fermented grains and damaged grains.

These characteristics are determined by the environmental weather conditions during production, crop production practices, soil conditions, harvesting, and post harvest practices

Moisture content

Moisture content has a marked influence on all aspects of paddy and rice quality and it is essential that paddy be milled at the proper moisture content to obtain the highest head rice yield. Paddy is at its optimum milling potential at moisture content of 14% wet weight basis. Grains with high moisture content are too soft to withstand hulling pressure which results in grain breakage and possibly pulverization of the grain. Grain that is too dry becomes brittle and has greater breakage. Moisture content and temperature during the drying process is also critical as it determines whether small fissures and/or full cracks are introduced into the grain structure.

Degree of purity

Purity is related to the presence of dockage in the grain. Dockage refers to material other than paddy and includes chaff, stones, weed seeds, soil, rice straw, stalks, etc. These impurities generally come from the field or from the drying floor. Unclean paddy increases the time taken to clean and process the grain. Foreign matter in the grain reduces milling recoveries and the quality of rice and increases the wear and tear on milling machinery.

Varietal Purity

A mixture of varieties causes difficulties at milling and usually results in reduced capacity, excessive breakage, lower milled rice recovery and reduced head rice. Different sizes and shaped grains make it more difficult to adjust hullers, whiteners and polishers to produce whole grains. This results in low initial husking efficiencies, a higher percentage of re-circulated paddy, non-uniform whitening, and lower grade of milled rice.

Grain dimensions

Grain size and shape (length-width ratio) is a varietal property. Long slender grains normally have greater breakage than short, bold grains and consequently have a lower milled rice

recovery. The grain dimensions also dictate to some degree the type of milling equipment needed. For instance, the Japanese designed milling equipment may be better suited to short-bold , japonica grains whereas Thai made equipment will be more suitable for longer, slender grain types.

Cracked grains
Overexposure of mature paddy to fluctuating temperature and moisture conditions leads to development of fissures and cracks in individual kernel. Cracks in the kernel are the most important factor contributing to rice breakage during milling. This results in reduces milled rice recovery and head rice yields.

Immature grains
The amount of immature paddy grains in a sample has a major affect on head rice yield and quality. The immature rice kernels are very slender and chalky and this results in excessive production of bran, broken grains and brewer's rice. The optimal stage to harvest grain is at about 20-24% grain moisture or about 30 days after flowering. If the harvest is too late, many grains are lost through shattering or dry out and are cracked during threshing, which causes grain breakage during milling

Damaged grains
Paddy deteriorates through biochemical change in the grain, the development of off-odors and changes in physical appearance. These types of damage are caused from water, insects, and heat exposure.

Yellowing
Yellowing is caused by over-exposure of paddy to wet environmental conditions before it is dried. This results in a combination of microbiological and chemical activity that overheats the grain. These fermented grains frequently possess partly gelatinized starch cells and generally resist the pressures applied during grain milling. While the presence of fermented grain does not affect milling yields it does downgrade the quality of the milled rice because of the unattractive appearance.

Insect- or mold-damaged grains can be distinguished by the presence of black spots around the germ end of the brown rice kernel which are caused by the microorganisms, insects, or a combination. Mold damage in particular is increased by unfavorable weather conditions. In the process of milling, these black spots are only partly removed which consequently increases the presence of damaged grains.

Quality characteristics of milled rice

The quality characteristics of milled rice are classified both physically, and chemically.

Review the following terms before reading about physical and chemical characteristics of milled rice:

- Paddy or rough rice = similar term for paddy, or rice retaining its husk after threshing
- Brown rice or husked rice = paddy from which the husk has been removed
- Milled rice = rice after milling which includes removing all or part of the bran and germ from the husked rice
- Head rice = milled rice with length greater or equal to three quarters of the average length of the whole kernel
- Large brokens = milled rice with length less than three quarters but more than one quarter of the average length of the whole kernel
- Small brokens or "brewers rice" = milled rice with length less than one quarter of the average length of the whole kernel
- Whole kernel = milled rice grain without any broken parts

- Milling recovery = percentage of milled rice (including brokens) obtained from a sample of paddy.
- Head rice recovery = percentage of head rice (excluding brokens) obtained from a sample of paddy.

Physical characteristics

Milling degree
The degree of milling is a measure of the percent bran removed from the brown rice kernel. Milling degree affects milling recovery and influences consumer acceptance. Apart from the amount of white rice recovered, milling degree influences the color and also the cooking behavior of rice. Unmilled brown rice absorbs water poorly and does not cook as quickly as milled rice. The water absorption rate improves progressively up to about 25% milling degree after which, there is very little effect.

Head rice
"Head rice" or head rice percentage is the weight of head grain or whole kernels in the rice lot. Head rice normally includes broken kernels that are 75-80% of the whole kernel. High head rice yield is one of the most important criteria for measuring milled rice quality. Broken grain has normally only half of the value of head rice. The actual head rice percentage in a sample of milled rice will depend on both varietal characteristics (i.e. the potential head rice yield), production factors, and harvesting, drying and milling process. In general harvesting, drying, and milling can be responsible for some losses and damage to the grain.

Whiteness
Whiteness is a combination of varietal physical characteristics and the degree of milling. In milling, the whitening and polishing greatly affect the whiteness of the grain. During whitening, the silver skin and the bran layer of the brown rice is removed. Polishing after whitening is carried out to improve the appearance of the white rice. During polishing some of the bran particles stick to the surface of the rice which polishes and gives a shinier appearance.

Chalkiness
If part of the milled rice kernel is opaque rather than translucent, it is often characterized as "chalky". Chalkiness disappears upon cooking and has no effect on taste or aroma, however it downgrades milled rice. Excessive chalkiness is caused by interruption during the final stages of grain filling. Though chalkiness disappears upon cooking and has no direct effect on cooking and eating qualities, excessive chalkiness downgrades the quality and reduces milling recovery.

Chemical characteristics

Gelatinization temperature
The time required for cooking milled rice is determined by gelatinization temperature or GT. Environmental conditions, such as temperature during ripening, influence GT. A high ambient temperature during development results in starch with a higher GT. GT of milled rice is evaluate by determinining the Alkali spreading value. In many rice-growing countries, there is a distinct preference for rice with intermediate gelatinization temperature.

Amylose content
Starch makes up about 90% of the dry matter content of milled rice. Starch is a polymer of glucose and amylose is a linear polymer of glucose. The amylose content of starches usually ranges from 15 to 35%. High amylose content rice shows high volume expansion (not necessarily elongation) and high degree of flakiness. High amylose grains cook dry, are less tender, and become hard upon cooling. In contrast, low-amylose rice cooks moist and sticky. Intermediate amylose rice are preferred in most rice-growing areas of the world, except where low-amylose japonicas are grown.
Based on amylose content, milled rice is classified in "amylose groups", as follows:

- waxy (1-2% amylose),
- very low amylose content (2-9% amylose),
- low amylose content (10-20% amylose),
- intermediate amylose content (20-25% amylose) and
- high amylose content (25-33% amylose).

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

Gel consistency

Gel consistency measures the tendency of the cooked rice to harden after cooling. Within the same amylose group, varieties with a softer gel consistency are preferred, and the cooked rice has a higher degree of tenderness. Harder gel consistency is associated with harder cooked rice and this feature is particularly evident in high-amylose rice. Hard cooked rice also tends to be less sticky. Gel consistency is determined by heating a small quantity of rice in a dilute alkali.

Paddy quality determination

Collect two samples of approximately 500 grams of fresh paddy, and determine the following characteristics by following the procedures as outlines above. Use the sheet to record your findings

- Moisture content (oven method, and moisture meter)
- Grain dimensions (L/W ratio)
- Dockage-weeds
- Dockage-inert matter
- Insects (dead, alive)
- Cracked grains
- Unfilled or immature grains
- Discolored and damaged grains
- 1000 kernel weight

Sheet exercise 1. Quality of paddy or rough rice

Parameters	**Sample 1**			**Sample 2**		
	No. grains (start)	**No. grains (finish)**	**(%)**	**No. grains (start)**	**No. grains (finish)**	**(%)**
Moisture (oven)						
Moisture (meter)						
L/W ratio						
Dockage-weeds						
Dockage-inert						
Insects						
Cracked grains						
Immature grains						
Discolored/damaged						
1000 kernel wt.						

Procedures for Measuring quality of paddy grain

Crack Detector

Using the Paddy Crack Detector, count the number of cracked grains in a 100 grain sample then

compute the % cracked grains using the equation:

$$\% \text{ Cracked grains} = \frac{\text{Number of cracked grains}}{\text{100 grains}} \times 100$$

Grain Dimensions
Using a caliper or photographic enlarger, collect 20 paddy samples at random from each replicate and measure the dimensions to obtain the average length and width of the paddy grains. To obtain the paddy shape, the following equation can be used:

$$\text{Length to width ratio (L/W)} = \frac{\text{Average paddy length, mm}}{\text{Average paddy width, mm}}$$

Paddy can classified based on International Organization for Standardization (ISO) for paddy

Immature Grains
Select a 25 gm grain sample and select, segregate and weigh the immature grains in sample. Calculate the percentage immature grains in the sample using the formula:

$$\% \text{ Immature grains} = \frac{\text{Wt. of immature grains}}{\text{Total weight of samples}} \times 100$$

Dockage in Paddy
Remove light foreign matter, stones, weed and seeds from a 100gm sample. Obtain the total weight then compute the dockage percentage as follows:

$$\% \text{ Dockage} = \frac{\text{Wt. of dockage}}{\text{Total wt. of sample}} \times 100$$

1000 Kernel Weight
Determined by counting and weigh 1,000 grains (paddy).

Procedures for Measuring quality of milled rice

Milling degree
Milling degree is computed based on the amount of bran removed from the brown rice. To obtain the weight of brown rice, dehull the paddy samples using the Laboratory Huller.
Estimate the percent milling degree using the following equation:

$$\% \text{ Milling degree} = \frac{\text{Wt of milled rice}}{\text{Wt of brown rice}} \times 100$$

Milling recovery
Using the Abrasive Whitener, mill the dehulled samples. Compute milling recovery by dividing the weight of milled rice recovered by the weight of the paddy sample, as follows:

$$\% \text{ Milling recovery} = \frac{\text{Wt of milled rice}}{\text{Wt of sample used}} \times 100$$

Dockage in Milled Rice

Select, segregate and weigh the foreign matter. Record the number of unhulled grains collected from the sample. Determine the percentage of dockage of milled rice using the equation:

$$\% \text{ Dockage (mr)} = \frac{\text{Wt. of dockage}}{\text{Total wt. of milled rice}} \times 100$$

Broken grain

Using the Grain Grader, separate the broken grain from the whole grains. Compute the percentage of the head rice and brokens using the following equations:

$$\% \text{ Head rice} = \frac{\text{Wt of whole grains}}{\text{Wt of paddy samples}} \times 100$$

$$\% \text{ Brokens} = \frac{\text{Wt of broken grains}}{\text{Wt of paddy samples}} \times 100$$

Chalkiness

A visual rating of the chalky proportion of the grain is used to measure chalkiness based on the standard Evaluation System SES scale presented below:

Scale	**% area of chalkiness**
1	less than 10
5	10-20
9	more than 20

Select, segregate and weigh the chalky grains (SES Scale 9). Determine the % chalky grain using the equation:

$$\% \text{ Chalky grain} = \frac{\text{Wt of chalky grains}}{\text{Wt of milled rice}} \times 100$$

Whiteness

Measure the grain whiteness using the Whiteness Meter. Separate and weigh yellow-fermented grains. Calculate the percentage of yellow/fermented grains using the formula:

$$\% \text{ Yellow grains} = \frac{\text{Wt. yellow grains}}{\text{Total wt. of milled rice}} \times 100$$

Grain Shape

Follow the procedure of determining grain shape of paddy. Based on the length to width ratio, the shape of the milled rice will be determined. L/W ration is given by:

$$\text{L/W ratio} = \frac{\text{Average length of rice, mm}}{\text{Average width of rice, mm}}$$

The ISO Classification is as follows:

Scale	Shape	L/W ratio
1	Slender	Over 3.0
3	Medium	2.1 – 3.0
5	Bold	1.1 – 2.0
9	Round	1.0 or less

1000 grain weight
Count and weigh 1,000 whole grains.

Amylose content.
Select twenty grains and ground them in a Cyclone Mill. Amylose content is analyzed using the simplified iodine colorimetric procedure. Samples are categorized into low, intermediate and high based on the following grouping:

Category	%Amylose Content
Waxy	1-2
Very low amylose	2-9
Low	10-20
Intermediate	20-25
High	25-30

Gelatinization temperature (GT)
GT is measured by determining the alkali-spreading value for which the alkali digestibility test is employed. Grains are soaked in 1.7% KOH and incubated in a 30oC oven for 23 hours. Measurement ranges are based on the following: Gelatinization temperature is estimated by the extent of alkali spreading and clearing of milled rice soaked in 1.7% KOH at room temperature or at 39oC for 23 hours. The degree of spreading is measured using a seven-point scale as follows:

1. grain not affected
2. grain swollen,
3. grain swollen, collar incomplete and narrow,
4. grain swollen, collar complete and wide,
5. grain split or segmented, collar complete and wide,
6. grain dispersed, merging with collar; and
7. grain completely dispersed and intermingled.

Category	Temp ranges (°C)	Alkali Spreading Value
Low	55-69	6-7
Intermediate	70-74	4-5
High	75-79	2-3

Gel consistency
Select from two to 10 grains and ground separately in the Wig-L Bug. Gel consistency is measured by the cold gel in a horizontally-held test tube, for one hour. Measurement ranges and category are as follows:

Category	Consistency, mm
Soft	61-100
Medium	41-60
Hard	26-40

Standards and grades for milled rice

Standards can be defined as a quantitative way by which we measure and compare certain quality characteristics. This measured comparison of recognizable quality characteristics can described as ‘grading’.

To date, there are few universally accepted international standards for paddy and milled rice. This is primarily due to a differences in emphasis on the importance of grading paddy and milled rice quality among countries. However, national standards exist and are being used as a marketing basis. As an example, the table shows national standards for milled rice in the

Philippines.

Grade Specifications	GRADE			
	Premium	Grade 1	Grade 2	Grade 3
Head rice (min %)				
Brokens (max %)				
Brewers (max %)				
Defectives:				
• Damaged grains, max %	0	0.25	0.50	2.00
• Discolored grains, max %	0.50	2.00	4.00	8.00
• Chalky and immature grains, max %	2.00	5.00	10.00	15.00
• Red grains, max %	0	0.25	0.50	2.00
• Red streaked grains, max%	1.00	3.00	5.00	10.00
Foreign matter (max %)	0	0.10	0.20	0.50
Paddy (max no./kg)	1	8	10	15
Moisture content (max %)	14.00	14.00	14.00	14.00

Quality standards for milled rice in Philippines (National Food Authority)

In general, grading factors for paddy are (1) purity, (2) foreign matter, (3) defectives and (4) moisture content. For milled rice, the characteristics considered for grading are (1) head rice, brokens and brewers percentages (2)defectives, (3) foreign matter, (4) presence of paddy and (5) moisture content.

Objectives of establishing standards and grades

1. to ensure only edible rice reaches the consumer;
2. to improve postharvest practices so as to eliminate or reduce waste;
3. to improve agronomic practices to increase farm yields;
4. to improve processing practices for better milling recoveries and for market expansion and
5. to protect consumers from price/quality manipulation.

In relation to the first objective, the characteristics such as moisture content, foreign material, seeds and discolored (damaged) grains are important considerations in assuring that only edible rice reaches the consumers. By setting standards for degree of milling, broken rice content, moisture and damaged grains, the second objective is addressed. Better threshing and drying, and improved storage facilities are expected to emerge to meet the required standard. The third objective provides incentives to the farmer/agricultural scientist to optimize production by considering standards for chalkiness, varietal purity, foreign seeds, immature grains and red rice. The fourth objective provides a measure of the miller's success in delivering high milling recovery and allowing the market expansion. Characteristics considered are standards for degree of milling, broken rice, paddy kernels and foreign matters. Finally, standards which clearly identify to consumers the true value of their purchases will provide the protection required against the possibility of unfair trading practices.

Comparison of rice mill output

Select a homogenous sample of paddy and run trials with different husking/whitening/polishing equipments, such as Satake abrasive mill, an Engleberg Rice Mill, a one-pass rubber roll mill. Input results using the sheet. Make a comparative analysis of the results obtained.

- Moisture content
- Head rice percentage
- Brokens
- Chalkiness
- Whiteness
- Milling degree

- Heat damaged/discolored grains

Quality of milled rice

Parameters	Sample 1			Sample 2		
	No. grains (start)	No. grains (finish)	(%)	No. grains (start)	No. grains (finish)	(%)
Moisture content						
Head rice						
Broken						
Chalkiness						
Whiteness						
Milling degree						
Discolored grains						

Grade the milled rice samples based on the National standards of milled rice in the Philippines. Take recommendations on improving the paddy and rice grade.

Testing a Rice mill for performance and quality

Visit a rice mill and sample the paddy before milling, brown rice after husking and the milled grain after processing. At the same time, monitor the performance of the rice mill by collecting the outputs from all of the outlets from the mill over a given time period.

The following samples need to be collected and weighed at the rice mill

- Head rice
- Course brokens
- Fine brokens
- Brewers rice
- Course bran
- Fine bran (“meal”)
- Husk

Time
Samples will be collected for 10 minutes from each outlet. An open woven bag will be necessary to collect the husk.

Weighing
Use the miller’s scales

Sub-sampling
Sub samples will be taken from each of the outlets so that they can be analyzed in the laboratory

Sheet 1

Rice mill performance

Date _____
Name _____
Address _____
Other data
Replace rollers (tons) _____
Reface stones (tons) _____
Fuel consumption (l/hr) _____
Storage capacity (tons) _____

	Test 1			Test 2			Test 3		
	Time	kg	%	Time	kg	%	Time	kg	%
Moisture content									
Head rice									
Large broken									
Medium broken									
Small broken									
Chips (brewers)									
Bran									
Husk									

Sampling times. Sampling times will depend on the capacity of the mill. A good benchmark is to collect from each outlet for at least 10 minutes.

Expected outputs. A good quality mill will produce 55% head rice, 15% brokens, 10% bran and 20% husk, all on % paddy weight basis

Sampling outputs. Collect a grain sample from the paddy, brown rice and from all stages of the process. Check the list.

Sample	**Collect (yes)**	**Sample**	**Collect (yes)**
Paddy		Head rice	
Brown rice		Large broken	
Ist whitener		Medium	
2nd whitener		Small	
Polisher		Brewers	
Bran		Husk	

Make an assessment of where in the rice mill improvements could be made to improve the milling output.

A. Insects

Insects in stored rice can be classified into four groups according to their feeding habits namely internal feeders, external feeders and scavengers.

1. Internal Feeders

These are insects whose larvae feed entirely within the kernels of the grain. These includes rice weevil, angoumois grain moth and lesser grain borer.

Rice Weevil (*Sitophilos oryzae* (Linnaeus)): Adults and larvae feed on a wide variety of grains. Female deposits a single egg in the grain by boring a hole inside. The egg stays in the grain until it becomes an adult thus making the grain completely damaged.

Angoumois Grain Moth (*Sitatroga cerealella* (Olivier)): Eggs are laid on or near grain. The white larvae bore into the kernels of the grain and feed on the inside. When mature, the larvae eat its way to the outer portion of the grain, leaving only a thin layer of the outer seed coat intact. Pupation takes place just under the seed coat. When the adult emerges from the grain, it pushes aside the thin layer of seed coat leaving a small trap door covering its exit point from the kernel. They infest only the surface layer of bulk-stored grain, adults are unable to penetrate deeply.

Lesser Grain Borer (*Rhyzopertha dominica* (Fabricus)): The eggs are laid in the grain mass and larvae may enter the kernels and develop within or, they may feed externally in the flour-like dust that accumulates from the feeding of the adults and their fellow larvae.

2. External Feeders

External feeders are insects that feed from the outside of the grain even though they may chew through the outer coat and devour the inside.

Cigarette or Tobacco Beetle (*Lasioderma serricorne* (Fabricius)): Feeds on books, flax tow, cottonseed meal, rice, ginger, pepper, dried fish, crude drugs, seeds, pyrethrum powder, and dried plants.

Flat Grain Beetle (Cryptolestes pusillus (Schonherr)): The female places her eggs loosely in the grain mass. The larvae and adults are able to penetrate the seed coat of the undamaged grain.

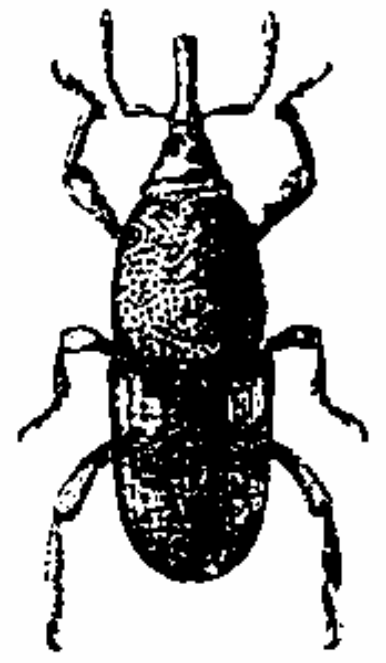
3. Scavengers

Scavengers feed on the grain only after the seed coat has been broken either mechanically or by some other insect.

Saw-toothed Grain Beetle (*Oryzaephilus surinamensis* (Linnaeus)): Eggs are usually laid, either singly or in small masses, in a crevice in the food supply but in items like flour, they are laid freely.

Pictures and main characteristics of the three main storage pests (sitophilus, tribolium, and ryzopertha):

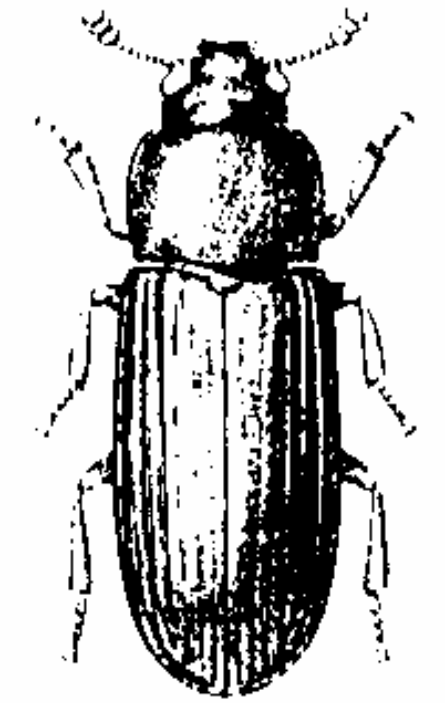
Sitophilus oryzae



Common name: Rico weevil
Family: Curculionidae
Description:
size: 2.5 - 3.5 mm
shape: more or less cylindrical
colour: black-brown with four reddish spots on the elytra
recognition: well defined snout: elbowed and clubbed antennae; circular punctures on the prothorax; can fly
Life history
range of temperature: 17 - 34℃
optimal temperature: 28℃
range of rel. humidity: 45 - 100%
optimal rel. humidity: 70%
eggs laid: up to 150 separately deposited inside the grain
life cycle: 35 days at optimum
110 days at sub-optimal conditions

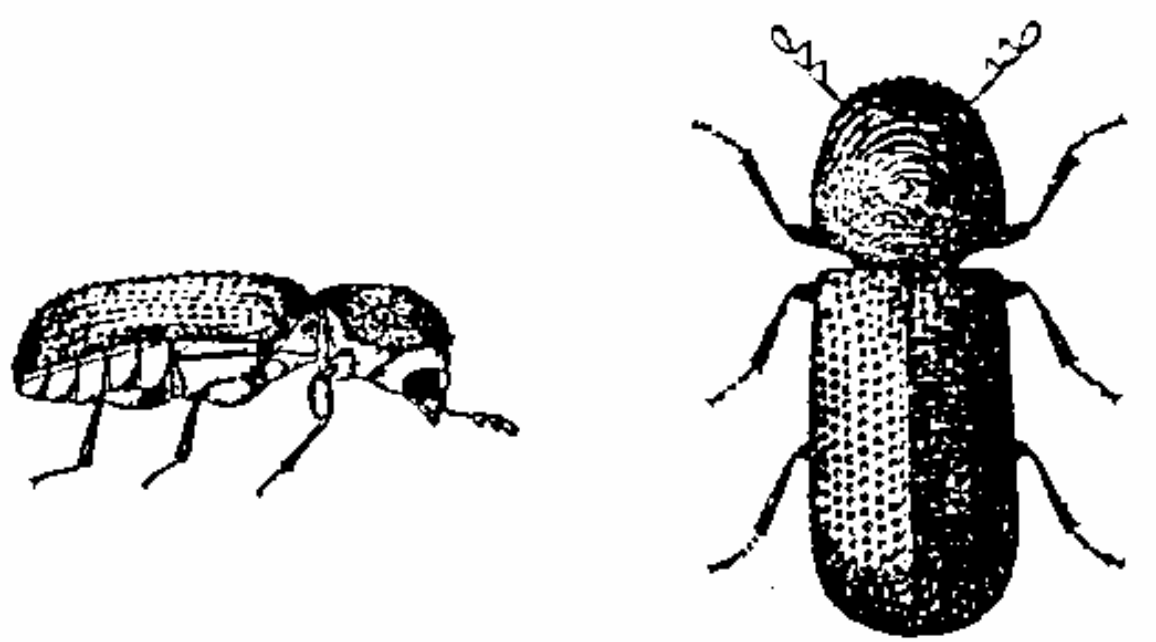
Damage
Adults and legless larvae are primary pests of cereals, rice and dried cassava. Larvae spend their lives inside the grain.

Tribolium castaneum



Common name: Rust-red flour beetle
Family: Tenebrionidae
Description
size: 3 - 4 mm
shape: elongate body, more or less parallel sided
colour: red brown - dark brown
recognition: antennae are inserted under the sides of the head (frontal ridge) and form a three-segmented club; elytra with finely punctured lines
Distribution: throughout the tropics and the subtropics
Life history
range of temperature: 22 - 40℃
optimal temperature: 35℃
range of rel. humidity: 1 - 90%
optimal rel. humidity: 75%
eggs laid: up to 500
life cycle: 20 days under optimum conditions
Damage
Larvae and adults are secondary pests and attack cereals and cereal products, groundnuts, nuts, spices, coffee, cocoa, dried fruit and occasionally pulses. Infestation leads to persistent disagreeable odours of the products.

Rhyzopertha dominica



Common name: Lesser grain borer
Family: Bostrichidae
Description
size: 2 - 3 mm
shape: slim, cylindrical
colour: red-brown to black-brown
recognition: head concealed beneath prothorax (typical for the Bostrichidae); prothorax bears marginal rows of teeth; elytra with well defined rows of punctures
Distribution: mainly in tropical and sub-tropical regions
Life history
range of temperature: 18 - 38℃
optimal temperature: 34℃
range of rel. humidity: 25 - 70%
optimal rel. humidity: 60 - 70%
eggs laid: 300 - 500 life cycle:20 - 84 days
Damage
Primary pest of cereal grains, other seeds, cereal products, dried cassava, etc. Damage is done by adults and larvae, which develop within the grain.

(source: Gwinner et al, Manual on the Prevention of Post-harvest Grain losses, GTZ, Escborn, 1996)

B. Rodents

Rodents are characterised by their teeth. They have a pair of incisor teeth in the upper and lower jaws. The incisors are curved inwards and have an extremely hard anterior coating. The softer inside layer is worn down much more rapidly than the hard, outer layer. This means that the teeth are continually kept sharp, enabling them to damage even materials such as masonry and electric cables. The incisors do not stop growing. This means that the animals are forced to gnaw steadily in order to wear them down.

The three most important rodent species are:

- Black rat or House rat *(Rattus rattus)*
- Norway rat or Common rat *(Rattus norvegicus)*
- House mouse *(Mus musculus)*

There are also a number of species which are of great importance in specific regions:

- Multi-mammate rat *(Mastomys natalensis)* in Africa and the Middle East;
- Bandicoot rat *(Bandicota bengalensis)* in Southern and South East Asia;
- Pacific rat *(Rattus exulans)* in South East Asia, also occurring in Southern Asia

Rats and mice cause losses in a number of ways:

- **Feeding on stored produce**

Rats eat an amount of food equivalent to 7% of their body weight daily, i.e. a rat with a body weight of 250 g will eat around 25 g daily, amounting to 6.5 kg of grain a year. Mice eat a daily amount equivalent to around 15% of their body weight, i.e. a mouse weighing 25 g will eat between 3 and 4 g a day, amounting to 1.4 kg of grain a year. Besides feeding on stored produce, actual losses are much higher, as rodents contaminate the stored produce with urine, faeces, hair and pathogenic agents. As it is extremely difficult if not impossible to remove filth produced by rodents from the stored produce, infested batches often have to be declared unfit for human consumption.

There are around 50 diseases which can be transferred to man by rodents, including typhoid, paratyphoid, and scabies. In addition, rodents may be vectors of a large number of diseases affecting domestic animals. The problems and costs resulting from these diseases are not normally taken into account when assessing infestation by rodents.

As rodents prefer food rich in proteins and vitamins and feed mainly on the embryo, they cause particular damage to the nutritional value and germination ability of seeds.

- **Damage to material and equipment** (e.g. tarpaulins, bags, pallets, sprayers) and to the store itself (cables, doors).

These often lead to subsequent damage:

- Produce leaking out of damaged bags or storage containers
- Bags stacks collapsing due to damage to the lower layers
- Short circuits leading to sparks or fire from cables being chewed
- Silos and warehouses may subside or even collapse as a result of being undermined
- Drainage canals around a store may be damaged.

Signs of rodent infestation

When there are signs of rodent infestation, it is necessary to conduct a thorough investigation of the store, its immediate surrounding area and neighbouring land.

There are a large number of clear signs of rodent infestation:

Live animals

Rodents are mainly active at night. If animals are nonetheless seen during the daytime, this is a sign of an already advanced stage of infestation.

Droppings

The shape, size and appearance of droppings can provide information as to the species of rodent and the degree of infestation. The droppings of Norway rats are around 20 mm in length and are found along their runs. The droppings of Black rats are around 15 mm long and are shaped like a

banana. Mouse droppings are between 3 and 8 mm in length and irregular in shape. Droppings are soft and shiny when fresh, becoming crumbly and matt black or grey in colour after 2 - 3 days.

Runs and tracks
Runs, such as those of Norway rats, are to be found along the foot of walls, fences or across rubble. They virtually never cross open areas of land, but always pass through overgrown territory, often being concealed by long grass.
Runs inside buildings can be recognized by the fact that they are free of dust. The animal's fur coming into contact with the wall leaves dark, greasy stains. Even Black rats, which do not have any fixed runs, can leave similar greasy stains at points which they pass regularly, e.g. when climbing over roof beams.

Footprints and tail marks
Rats and mice leave footprints and tail marks in the dust. If you suspect there might be rodent infestation, scatter some sort of powder (talcum powder, flour) on the door at several places in the store and later check for traces. The size of the back feet serves as an indication of the species of rodent:

- Back feet larger than 30 mm: Black rat, Norway rat, Bandicoot rat.
- Back feet smaller than 30 mm: House mouse, Multi-mammate rat, Pacific rat.

Tell-tale damage
Rats leave relatively large fragments of grain they have nibbled at (gnaw marks). They generally only eat the embryo of maize. Sharp and small leftovers are typical for mice. Rodent attack can further be detected by damaged sacks where grain is spilled and scattered. Small heaps of grain beneath bag stacks are a clear sign. These should be checked for using a torch on regular controls.
Attention should be paid to damaged doors, cables and other material.

Burrows and nests
Depending on their habits, rodents either build nests inside the store in corners as well as in the roof area or in burrows outside the store. Rat holes have a diameter of between 6 and 8 cm, whereas mice holes are around 2 cm in diameter. These holes can be found particularly in overgrown areas or close to the foundations of a store.

Urine
Urine traces are fluorescent in ultraviolet light. Where available, ultraviolet lamps can be used to look for traces of urine.

Preventive measures

The most essential factors for the occurrence of rodents are:

- sufficient supplies of food
- protected places in which to build burrows and nests
- hiding places
- access to produce

Good store management and preventive measures taken as part of an integrated control programme can help to deal with these factors.

Storage Hygiene and Technical Measures

- Keep the store absolutely clean! Remove any spilt grain immediately as it attracts rodents!
- Store bags in tidy stacks set up on pallets, ensuring that there is a space of I m all round the stack!

- Store any empty or old bags and fumigation sheets on pallets, and if possible in separate stores!
- Keep the store free of rubbish in order not to provide the animals with any places to hide or nest! Bum or bury it!
- Keep the area surrounding the store free of tall weeds so as not to give the animals any cover! They have an aversion to crossing open spaces.
- Keep the area in the vicinity of the store free of any stagnant water and ensure that rainwater is drained away, as it can be used as source of drinking water.

Keeping Rodents Out

The requirements of preventive rodent control must be taken into account whenever new stores are being built. Particular attention should be paid to doors, ventilation openings, brickwork and the junctions between the roof and the walls. Repair any damage to the store immediately! This applies especially to the doors.

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