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UNIDO TECHNOLOGY MANUAL

Small-scale Cereal Milling and Bakery Products

Production methods, equipment and quality assurance practices

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

economy environment employment

UNIDO Technology Manual

Small-scale Cereal Milling and Bakery Products

Production Methods, Equipment and Quality Assurance Practices

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2004

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This manual has been prepared by A. Ouaouich, team leader of the Uganda Integrated Programme, based on the work of Peter Fellows, UNIDO Consultant, in cooperation with the project team.

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Preface

UNIDO has emphasized micro/small-scale business development in its technical assistance programmes as a mean to contribute to economic growth and poverty reduction in Africa in general and Uganda in particular. This technology manual is an important tool that contributes to the capacity building activities carried out by UNIDO in the small-scale food-processing sector within the framework of the Integrated Programme.

Cereal processing offers good opportunities for small-scale businesses in Uganda because raw materials are readily available, most equipment is reasonably affordable and if the products are chosen correctly, they have a good demand and can be profitable. However, small-scale cereal processors are confronted with strong competition in the domestic and regional markets. To be profitable it is essential to have high quality products, an attractive package where appropriate and a well-managed business.

The purpose of this manual is to guide the small-scale cereal miller and baker in Uganda to optimize their processing methods and implement GMP (Good Manufacturing Practices) and quality assurance schemes and build their technical capacity for improved market access and competitiveness.

Different types of food processing can be categorized into:

1) Primary processing (post-harvest operations including drying, milling, etc.).
2) Secondary processing (e.g. baking, frying etc.) in which raw materials from primary processing are transformed into a wide range of added value products that are attractive and add variety to the diet.

This manual covers technical aspects of cereal processing to produce safe and high quality products. It does not deal with the many other aspects of operating a successful small business such as marketing, business and financial planning and management skills. Institutions listed in Annex A can provide more information on these topics. They are also covered by training opportunities being developed by the Uganda Cottage Scale Food Processors Association under the UNIDO Uganda Integrated Programme.

Hand in hand with good manufacturing, hygiene and management practices, all partners in the food supply chain must remain aware of the expanding number of domestic and international food safety laws and regulations. Several incidences of food contamination have led the Codex Alimentarius Commission to develop additional food safety standards to enhance consumer health protection. These food safety laws, regulations and standards are mandatory. To access markets, food commercial enterprises must meet them through the application of Good Manufacturing/Hygienic Practices (GM/HP) and Hazard Analysis Critical Control Point (HACCP). The implementation of sound quality assurance programmes is also a must to increase their competitiveness.

The facilities needed for commercial food processing are described in Section 2. Production planning techniques and processing methods for common cereal products in Uganda are described in Sections 3 and 4. Details of production techniques and equipment for various bakery products and service and maintenance requirements are given in Section 5. Quality assurance methods are referenced in every section and summarized in Section 6, where there is additional information on international and domestic food safety requirements, laws and standards.

How to use this manual

The information contained in this Technology Manual is intended to serve three purposes:

1. It is a resource for trainers who work with small-scale cereal processing entrepreneurs at pilot centres established under the UNIDO Uganda Integrated Programme: Enhanced Competitiveness and Sustainability of Industrial Development - Agro-industries and Micro/Small-scale Enterprises.

2. It is a reference manual to assist entrepreneurs to continue to improve the technical aspects of their businesses after training.

3. It is a reference manual that outlines practices and procedures for the production of safe, high quality cereal-based products and for the development of Good Hygienic Practices (GHP) and Good Manufacturing Practices (GMP) programmes that will serve as the foundation for the preparation of a Hazard Analysis and Critical Control Point (HACCP) system.

Where appropriate, there are worked examples of calculations to assist entrepreneurs to develop their skills, particularly in production planning. Throughout the text there are checklists of important points to enable processors to assess their present quality and food safety practices. This will enable processors and producers to identify where production, processing, hygiene and food safety improvements are needed.

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1 Introduction to Milling and Processing

Both milling and secondary processing are major sources of income for thousands of people in Uganda. In custom milling (also known as 'contract' or 'service' milling), customers bring their grain to a mill and have it ground for either a small fee or a proportion of the flour. It is popular in rural areas and in less affluent districts of urban centres, where it provides a service to low-income customers who may not be able to afford packaged flour from retailers. However, in Uganda the majority of millers pack their flour into retail bags. Retail packs compete with flour that is sold in open markets from sacks, usually at a lower price. The miller must therefore offer potential consumers a reason to buy more expensive flour in packets. Benefits such as guaranteed quality; freedom from stones or other contaminants; and a guaranteed weight can be promoted as positive benefits to consumers. Wholesale or institutional markets are more diverse and include sales to schools and colleges, other government institutions (prisons, army barracks etc.), international food relief operations, bakeries and wholesalers (who in turn supply retailers and/or bakeries). Wholesale or institutional customers are more likely to be professional buyers who are experienced at negotiating prices, terms and conditions of sale and buy flour using contracts and open tenders.

After cereals have been ground to flours, they can be processed in a variety of ways and combined with potentially hundreds of other ingredients to produce a vast range of processed cereal products. Wheat flour is an essential ingredient in most bakery products, but it is not produced at a small scale in Uganda. Wheat is either milled in large-scale centralised mills (e.g. at Jinja) or flour is imported. Wheat milling is, therefore, not included in this manual. Successful small-scale bakers offer a range of bakery products (e.g. cakes, pies and pastries) and not just bread. This is because they are in competition with larger bakeries that have greater economies of scale and can sell bread more cheaply. Although a range of products needs more careful production planning (Section 3), it spreads the financial risk and these products have higher profit margins than bread. When bakers make a wide product range, they gain a reputation for innovation and attract customers who are looking for something different, or place special orders (e.g. for birthday or wedding cakes, snacks for parties etc.). It also demonstrates the skill and professionalism of the baker and customers then gain confidence in the quality of the products. In recent years new, non-traditional cereal products have entered the Ugandan market to meet changing demands of richer urban populations and visitors. Bakery products such as cakes and pastries and 'fast-foods' such as pizza, pies and fried cereal products (e.g. samosas and doughnuts) have growing markets in urban centres.

Cereal processing, therefore, offers very good opportunities for small-scale enterprises. The technology is available and affordable, the demand for products is high and the level of skill and expertise needed to produce high quality products is lower than in many other types of food processing. The main types of milled and baked products produced by small-scale processors in Uganda are shown below.

Milled products		Bakery products	
Composite flours Finger millet flour Legume flours	Maize flour Rice flour Sorghum flour	Biscuits/cookies Breads Cakes Doughnuts	Pastries Pies Pizzas Samosas

Table 1.1 – Types of processed cereal products

Checklist 1

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.

Question	Tick	Notes
1. What types of spoilage can affect your products?		
2. Do you know how long your raw materials can be stored before they begin to spoil?		
3. What are the main harvest times for your raw materials?		
4. Do you know how to handle crops to minimise damage and spoilage?		
5. Do you save money to buy crop at harvest or manage your cash flow to make funds available for buying crop?		
6. Do you have the organisational skills to process a succession of crops throughout the year?		

2 Production Facilities

This section summarises the facilities needed in a small flourmill or bakery.

The site

The best location for a mill depends on whether it needs to be close to customers or close to the source of raw materials. Millers who sell their flour to wholesalers or institutions throughout the country do not need to be close to them. Those who have a local retail market may benefit from being close to their customers. Regardless of whether the mill is located in an urban or a rural area, there should be a suitable nearby site for disposal of waste hulls and wastewater. Noise and dust from the mill should not cause a nuisance to neighbours.

Bakeries usually have local customers and, in contrast to flourmills, many products have a short shelf life. A bakery should therefore be located close to customers in a busy residential or industrial area, provided smoke from ovens does not cause a nuisance to neighbours. Bakeries do not produce much waste and it can be burned or taken for disposal by local authorities.

The building

All cereal processing businesses should have a hygienically designed and easily cleaned building to prevent contamination of products. Buildings in rural areas may cost more to construct because of higher transport costs for building materials, but rents in rural areas are usually lower than urban centres. The investment in construction or the amount of rent paid should be appropriate to the size and expected profitability of the business. Within the building, raw materials and food products should move between different stages in a process without the paths crossing. This reduces the risk of contaminating finished products, as well as reducing the likelihood of accidents or of operators getting in each other's way. There should be enough space for separate storage of raw materials, ingredients, packaging materials and finished products. Toilets should be separated from the processing area by two doors or in a separate building.

Make sure that the building is big enough for your production, but do not pay for extra space that you do not need.

When designing the layout of a mill or bakery, it is important to ensure that:

- The best use is made of the available space
- Food passes from one process stage to the next in a straightforward way, without causing operators to block each other's workspace and
- Sufficient space is left around equipment for maintenance and cleaning.

The building should have sufficient space for the intended scale of operation and include:

- Space for weighing and inspecting incoming grain or flour
- Space for raw material storage
- Space for production
- Space for packing and storage of products
- Space for maintenance and repairs of equipment
- Space for customers (customers should not be allowed into the processing area)
- Cupboard for spare parts and tools
- First aid box and sand bucket or fire extinguisher
- Hand-washing and toilet facilities, with space to store workers' clothes.

The most important consideration in the design of mills and bakeries is to prevent dust, insects and rodents. Flour dust contaminates products, attracts pests that in turn contaminate products, causes a health hazard to staff, damages equipment and has the potential to cause a fire or explosion[1]. Dust accumulation is prevented by good housekeeping, correct maintenance of equipment (Section 5) and routine cleaning (Section 6). All mills and bakeries should have fire extinguishers or sand buckets that is easily accessible.

Roofs and ceilings

Overhanging roofs made from fibre-cement tiles are better than galvanised iron sheets to reduce heat from the sun. High ceilings allow heat to rise up away from operators and escape from the building and good ventilation is needed near to bakery ovens. A panelled ceiling should be fitted in processing and storage rooms, rather than exposed roof beams, which allow dust to accumulate and fall off in lumps to contaminate products. Beams are also paths for rodents and birds, creating contamination risks from hairs, feathers or excreta. It is important to ensure that there are no holes in the panelling or roof and no gaps where the roof joins the walls, which would allow pests to enter.

Walls, windows and doors

All internal walls should be plastered or rendered with concrete. The surface finish should have no cracks or ledges, which could harbour dust or insects. Walls should either be tiled or painted with waterproof white gloss paint or good quality emulsion paint.

Natural daylight is better and cheaper than electric lighting in processing rooms. The number and size of windows depends on the amount of money that a processor has to invest and the security risk in a particular area (windows are more expensive than walls, especially when security bars or grilles are needed). Storerooms do not need to have windows. Windows should be screened with mosquito mesh. Windowsills should be made to slope, to prevent dust accumulating and to prevent operators leaving cleaning cloths or other items lying there, which can attract insects.

Doors should be close fitting without gaps around them. Storeroom doors should be kept closed to prevent insects and rodents getting in. Normally doors in processing rooms should be kept closed, but if they are used regularly there is a tendency for them to be left open.

---

[1] Dust can be ignited by a spark from an electric motor or by static electricity. (Static electricity is an electrical charge on an insulating aterial, such as nylon clothing, which can create a spark when the material is earthed).

Thin metal chains, or strips of plastic or cloth can be hung from door lintels to deter insects and some animals, while allowing easy access for staff, or mesh door screens can be fitted.

Floors

Floors in processing rooms and storerooms should be made of good quality concrete, smooth finished and without holes or cracks. Dust can collect in corners where the floor and the walls join and to prevent this, the floor should be curved up to meet the wall. In flour mills the floors should be at least 30 cm thick to accommodate the bolts used to fix down the mill.

REMEMBER
The Uganda National Bureau of Standards will inspect each of the above aspects of your production facilities before they will award a product registration certificate

Services

Lighting and power

Where lighting is needed, florescent tubes use less electricity than bulbs, but care is needed when using fluorescent lights above mills, dehullers and other equipment that has moving or rotating parts. This is because they can make machinery appear stationary at certain speeds, causing a hazard to operators. Electricity is preferred for bakery ovens because it is clean, flexible and easily controlled. Electric motors should be fitted with isolators and starters. Plugs should be fitted with fuses that suit the power rating of the equipment and the main supply should have an earth-leakage trip switch. All electric wiring should be of the correct type for the intended purpose and installed by a qualified and competent electrician. Where a three-phase (440 volt) supply is used in larger mills, the load should be equally spread over the three phases. Multiple sockets should not be used because they risk overloading a circuit and causing a fire. Cables should be properly fixed to walls or run vertically from the ceiling to machines. There should be no exposed wires at any connection.

Water supply and sanitation

Water is used in bakeries to make dough and for washing equipment. An adequate supply of **potable** (safe for drinking) water should be available from taps in the processing room. There are two potential problems with the water quality: sand and contaminating micro-organisms. Water from boreholes is likely to be relatively free from micro-organisms, but may be contaminated with sand. River water is likely to be contaminated with micro-organisms and should only be used if no other source is available. Samples of water should be periodically checked (e.g. once per year) for microbial contamination at the UNBS, Makerere University Department of Food Science and Technology, UIRI, or one of the commercial testing laboratories in Kampala. Because the amounts of water used in mills and bakeries are relatively small, any sediment can be removed by filtering. If micro-organisms are likely to contaminate the water, they can be removed by water filters, by boiling water for 10-15 minutes, or by dosing water with bleach (water for cleaning should be dosed by mixing 1 litre of bleach into 250 litres of water. Water that is used as an ingredient has 2.5 ml of bleach to 250 litres of water). Care is needed when using bleach because it damages the skin and particularly the eyes and can cause breathing difficulties if inhaled. It also corrodes aluminium equipment.

Potable water is drinking water that is wholesome and clean and does not cause illness. It is free from any micro-organisms and parasites and from any substances which, in numbers and concentration, constitute a potential danger to human health. It should meet the standards established by UNBS.

Good sanitation is essential to prevent contamination of raw materials and processed products by pests. Milling and bakery equipment should be thoroughly cleaned after each day's production, using a cleaning schedule that is clearly understood and followed by production workers. Insects and rodents are attracted to food that is left lying around and wastes should be removed each day and flour dust cleaned up. Wastes should not be left in a processing room overnight. Hulls and bran should be considered as by-products rather than wastes and sold to animal/poultry farmers or for use in alternative products (Section 3). Bulk stores of flour should be protected in a pest-proof storeroom and small amounts of ingredients should be stored in insect- and rodent-proof containers. Rodent traps are useful (but not poison) and if affordable, electric 'insectocuters' should also be used. A summary of guidelines on hygiene and sanitation is shown in Table 3.3.

Fuels

Diesel is the preferred fuel for mills/dehullers etc., where electricity is not available. In bakeries, fuel is one of the main costs if electric ovens are not used and the choice of fuel is one off the main factors that determines the profitability of a business. Different fuels have advantages and limitations in terms of cost, safety, risk of contamination of products, flexibility of use and capital and operating costs of the oven. The cheapest fuel is not always the most economical and it is necessary to carefully select the best fuel to use in a bakery. Traditionally, wood has been cheap or free in Uganda and so widely used in bakery ovens. However, deforestation in some areas has resulted in increased cost of wood and legal restrictions on tree felling. It also produces a light fluffy ash that can easily contaminate products. Charcoal is more expensive than wood, but it produces a more intense heat with little smoke and a more compact ash. Bottled gas (LPG) is available in large urban centres and as fuel prices are constantly changing, this may be cheap enough to compete with solid fuels. Other liquid fuels, such as kerosene or diesel are not widely used because of the special burners required and the risk of contaminating the product with off-odours. Petrol burners should not be used under any circumstances because of the risk of an explosion.

Energy conservation

Bakeries and mills use large amounts of energy and their profitability depends partly on reducing energy consumption. This can be done by only switching on mills, dehullers etc. when they are needed, or by baking a sequence of different products as ovens cool, to use all the available heat. Switching off lights in storerooms, or reducing vehicle fuel consumption by co-ordinating product deliveries with collection of ingredients or raw materials can make other savings. Other ideas include solar water heating (e.g. for washing equipment), the use of fuel briquettes made from bran rather than fuel-wood and using local suppliers of raw materials that can be delivered by bicycle, rather than using a vehicle to collect them. When everyone does this, it can result in national environmental and economic benefits by reducing deforestation and importation of fuels.

Checklist 2

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.

Question	Tick	Notes
1. Is your site close to supplies of raw materials?		
2. How can you reduce the cost of transporting raw materials to your site?		
3. Does the processing room have a panelled ceiling?		
4. Are the walls easily cleaned? What do you need to do to improve them?		
5. Are doors and windows protected against insects? If not what improvements do you need to make?		
6. Is the floor free of cracks and easily cleaned?		
7. Do you have drainage that is protected against entry by rodents?		
8. Are lighting and power adequate? What do you need to do to improve them?		
9. Are the amounts and quality of water adequate for processing?		
10. Do you have facilities for disposal of solid wastes and water that will not cause localised pollution?		
11. Do you have toilets and hand-washing facilities?		

3 Production Planning

Production planning involves thinking ahead to make sure that everything is in place to produce the required amount of product. This includes:

- Number of workers required and their different jobs
- Equipment needed to achieve the planned production level
- Quantities and specifications of raw materials and ingredients to be bought
- Number of packages required.

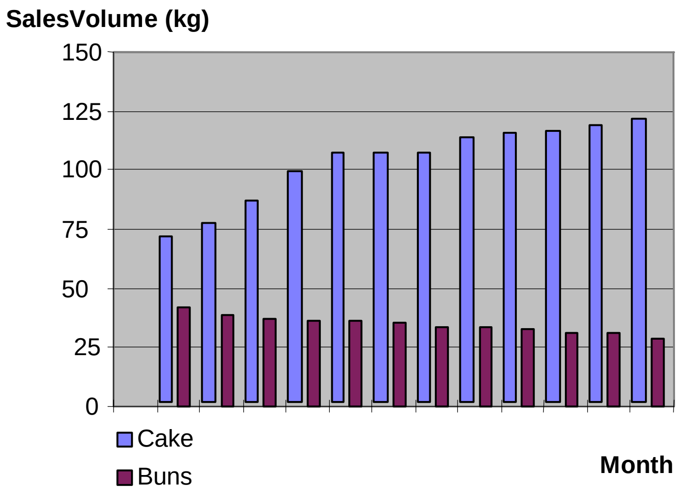
Poor production planning leads to stoppages or insufficient levels of production. If this happens frequently, the output falls below the planned capacity and the business cannot produce enough to pay the bills and it fails.

The information required to plan production includes:

- How much product is sold (not made) each month?
- How many hours are worked per day?
- How many days are worked per month?

The first step is getting detailed information on current sales for each product (Fig 3.1) by adding the daily sales figures to produce monthly totals (these figures also show trends in sales which can be used to plan for additional equipment, new staff, or development of new products).

Fig. 3.1. Hypothetical monthly sales chart



When starting up a business, projected sales information is used to find the daily production rate, so that ingredients and packaging can be ordered.

Production rate (kg/day) = $\frac{\text{amount of product sold/month (kg)}}{\text{N}^{\text{o}}\text{ days production/month}}$

Worked example 1: Calculation of production rate

From Fig 3.1:
Current cake sales are 124 kg per month. The bakery staff work on Monday to Friday each week with a half day on Saturday. Therefore in a four-week month: the production rate =

124/(5.5 x 4) = 5.6 kg/day

This data is also used to calculate the average amount of production per hour (termed the 'product throughput') to find the size of equipment and numbers of workers required.

Throughput (kg/hour) = $\frac{\text{amount of product sold/month (kg)}}{\text{N}^{\text{o}}\text{ days production/month x N}^{\text{o}}\text{ hours worked/day}}$

Worked example 2: Calculation of throughput

Using the data in Worked Example 3.1 and assuming that bakery staff work for 2 hours per day on cake making (other products are made during the remaining time), then the

Average throughput of cakes = 124/(5.5 x 4) x 2

= 2.8 kg/hour

The calculation in this worked example may need to be modified if for example, staff to produce cakes works only two days per week. In this case, the throughput would be 124/(2 x 4) x 2 = 7.75 kg/hour.

Every effort should be made to ensure that the production rate is calculated as accurately as possible by carefully checking all the figures and assumptions.

One of the main causes of error is to over-estimate the number of working days, particularly if there are for example, regular power failures or if staff members are often absent. The throughput figure allows the processor to decide the size and/or number of pieces of equipment that are required. In doing this, decisions need to be taken on the relative benefits of employing a larger number of workers or buying machinery to do a particular job (see also Worked Example 8).

Milling

Production planning in a flour milling business is more straightforward than in a bakery because there are fewer types of products or ingredients and different flours are made using the same equipment. When setting up a mill, the expected sales are used to decide the capacity of the mill. Other equipment (dehullers, bagging machines etc.) is then selected to match this capacity (see worked example 3).

Worked example 3: Establishing the capacity of a mill

From discussions with retailers (i.e. market research) a new miller finds that the sales of maize flour in a small town are estimated to be 300 tonnes per week. If the new business aims to capture 3% of this market, the amount of sales are 3% of (300 x 1000) kg = 9000 kg/week or 36,000 kg/month. If production is expected to take place for five days per week, milling for four hours per day (with the remaining time used for packing):

$$\text{The throughput (kg/hour) required for the mill} = \frac{\text{amount of product sold/month (kg)}}{\text{N}^{o}\text{ days production/month x N}^{o}\text{ hours worked/day}}$$

$$= \frac{36000}{(20 \times 4)}$$

$$= 450 \text{ kg/hour}$$

The main problem facing millers is to ensure an adequate supply of raw materials (often for a full year's production). To buy grains at the lowest prices, the crop must be bought at harvest time and this means that sufficient cash should be put aside to pay for the entire crop at one time. If this is not possible and crop has to be bought throughout the year, the changes in price may lead to difficulties in financial planning and production planning. An alternative, which is not too common in Uganda, is to contract farmers to supply the flour mill. This offers benefits to millers, including:

- An assured supply of grain and easier production planning because of guaranteed supplies
- Reduced uncertainty over the cost of grain (and income for farmers)
- Better understanding by farmers of millers' quality requirements

For any type of agreement to work, both parties must keep their side of the bargain and this requires a high level of trust and understanding.

Good production planning is also needed to control expenditure and reduce product costs. The main considerations are:

- Maintaining equipment to prevent breakdowns and ensure uninterrupted production
- Training staff to ensure high product quality
- Full utilisation of staff and machinery to maximise productivity.

Worked example 4: Full plant utilisation for profitability

A miller calculates that the total cost of producing maize flour (including rent, labour, materials, depreciation, bank charges etc.) is USh 360,000 per day. The output from the mill is 1800 kg/day at full capacity and all the flour can be sold for USh 300/kg.

At full capacity, the income = 1800 x 300
= USh 540,000 per day
and the profit/loss = 540,000 - 360,000
= USh 180,000 profit per day.

However, if machinery breakdowns, power failures or staff absences reduce the output of the mill to an average of 1000 kg/day, the figures are quite different:

Income = 1000 x 300
= USh 300,000
and profit/loss = 300,000 - 360,000
= USh 60,000 loss per day.

To maintain profitability, it is also important to reduce losses of material. Losses arise in milling during sorting, dehulling, or spillage of flour during the process, especially during filling into packs (Table 3.1). It is important that millers should measure the losses in their own processes so that accurate figures can be used in the calculations.

Table 3.1. Typical losses during milling

Stages in a Process	Typical Losses (%)
Sorting grain	5-20
Hulling	5-15
Packaging flour	2-10
Rejected flour	0-5

(Source: Fellows, P., Midway Technologies Ltd., Bonsall, UK)

The amount of usable flour after raw materials are milled is known as the 'yield' and is calculated as follows:

$$\textbf{Yield (\%)} = \frac{\text{weight of flour}}{\text{weight of raw material}} \times 100$$

The true cost of flour (excluding production costs) depends on the yield and can be calculated as below:

$$\textbf{True cost} = \frac{\text{Supplier cost}}{\text{\% yield}} \times 100$$

Worked example 5: Flour yield

A miller buys 1000 kg of maize for USh 50/kg and because of losses during processing (identified as 16% losses during sorting because of contamination by stones, losses of 5% during hulling and 5% flour loss during packing); the final weight of packaged flour is 740 kg.
The yield of flour = (740 / 1000) x 100
= 74%
and the true cost of the maize = (50 / 74) x 100
= USh 67.5 per kg (not USh 50 / kg)

By-products

Rice bran and maize hulls are the main by-products of milling and in some parts of Uganda these have little value and are allowed to accumulate outside mills. This creates a health and environmental hazard and also increases the risk of contaminating products in the mill. Millers may have to pay to have the bran removed to a disposal site, which increases the operating costs of the mill. There are potentially a number of ways in which this cost could be turned into another source of income:

1) Bran may be sold to local chicken or egg producers as poultry feed, or to livestock farmers where zero-grazing is practised. With additional investment, a separate feed-mill could be established to use the bran in pre-prepared animal feed rations.
2) Making fuel briquettes to replace charcoal for domestic cooking
3) Compressing the bran with glue as an alternative to wood for furniture making
4) Using it as reinforcing material to strengthen concrete blocks.

Details of these applications are outside the scope of this book, but readers are referred to UNIDO's Uganda Cleaner Production Centre at Nakawa for further information.

Baking

During set-up of a bakery, the expected sales of different products are used to plan production capacity (throughput) and this is then used to calculate the size of the mixer and oven required (See worked example 6). The throughput is also used to select the size of other equipment, storage racks, bins etc.

Worked example 6: Calculating the size of bakery equipment

A baker requires 180 kg of bread dough per day and has 3 hours to produce it.
The average throughput is therefore:

$$\frac{180}{3} = 60 \text{ kg/hour}$$

Dough is mixed for 15 minutes and three batches per hour are therefore possible. The capacity of the mixer should therefore be 60/3 = 20 kg (a bowl size of approximately 25 kg). Each batch of bread needs to be baked for 20 minutes and there are therefore two batches per hour. The oven should have a capacity of 30 kg. If 400g loaves are produced, the capacity of the oven should be 30,000/400 = 75 loaves.

During routine production, the amounts of ingredients to buy each week or month are based first on the recipe for the product and the likely levels of wastage or losses during the process (Worked example 7).

Worked example 7: Calculating weights of ingredients from a recipe.

Production target: 500 pieces of cake @ 100g each (50 kg total). Losses during preparation and baking = 10%. The recipe for cake is shown in the left column of the table below and the amounts of ingredients needed to make 50 kg are shown in the right column, with the calculation in the centre.

Product: Fruit cake	Calculation	Amount needed to make 50kg
Recipe:		
Flour: 168g	(168/600) x 50	14.0 kg
Baking powder: 2.6 g	(2.6/600) x 50	217g
Sugar: 98g	(98/600) x 50	8.2 kg
Water: 85g	(85/600) x 50	7.0 kg
Eggs: 40g	(40/600) x 50	3.3 kg
Shortening: 84.5g	(84.5/600) x 50	7.0 kg
Mango (pulped): 122g	(122/600) x 50	10.2 kg
Total 600g		**50.0 kg**

However, the amounts of ingredients that are calculated from the recipe are not the same as the amount of product that is made. Losses arise from dough or batter that sticks to equipment, evaporation of water during baking, broken or substandard products etc. It is important that bakers should measure the losses in their own processes so that accurate figures can be used in the calculations.

<u>Table 3.2. Typical losses during baking</u>

Stages in a Process	Typical Losses (%)
Batch preparation/weighing of bakery ingredients Baking (moisture loss) Machine washing Accidental product breakage Rejected packs	2-5 10-12.5 2-5 2-5 2-5

(Source: Fellows, P., Midway Technology Ltd., Bonsall, UK)

The amount of product compared to weight of ingredients is known as the 'yield' and is calculated as follows:

$$\textbf{Yield (\%)} = \frac{\text{weight of product}}{\text{weight of ingredients}} \times 100$$

The true cost of products depends on the yield and can be calculated as below:

$$\textbf{True cost} = \frac{\text{Supplier cost}}{\text{\% yield}} \times 100$$

During routine production, bakers should ensure that there are adequate amounts of ingredients for the different products and that the quality of ingredients is satisfactory (especially the quality of yeast, eggs or other perishable ingredients). Less perishable ingredients, such as sugar, salt, spices etc. and packaging materials can be stored as stock. The size of stocks depends on how easy it is to re-order the materials and this is different for bakers in more remote parts of Uganda compared to those in Kampala. If bakers buy large amounts of stock to protect themselves against unreliable supplies, the cash is tied up for many weeks while they are waiting to be used. Buying smaller quantities more often is more expensive than buying in bulk.

Packaging

Packaging is less of a problem for cereal processors than for other types of processing. Most millers pack flour in stitched paper bags or sacks and bakery products are packed in paper bags, polythene bags or paperboard cartons, if they are packaged at all. Cardboard, polythene and paper packaging is widely available and can usually be printed by local print companies (see UNIDO Food Processing Equipment Directory). The daily production rate above is also used to calculate the numbers of packages required.

Worked example 8: Calculation of number of packs required and time needed to fill and seal them

3 tonnes of maize flour are produced per day and half of it is packed into 500g bags. There are 20 bags in each distribution box:

$$\text{The number of bags required} = \frac{(3000/2) \times 1000}{500} = 3000 \text{ bags}$$

and the number of boxes = 3000/20 = 150 boxes

If on average it takes a worker 45 seconds to fill and seal a bag, the time required for one worker to pack the flour would be = 3000 x (45/60) minutes = 2250 minutes (37.5 hours)
Even if 4 people are working together, the time required is over 9 hours and clearly a semi-automatic bagging machine is required at this scale of production.

Equipment maintenance

Another reason for lost production is delays caused by waiting for spare parts after equipment breaks down. As a minimum, cereal processors should monitor the state of equipment that is likely to wear out and as their experience grows over the years, they should buy spare parts or send the machine for servicing when they expect that a component is due to be replaced. There are likely to be a few parts that wear out more quickly than others (e.g. mixer bearings, heating elements in bag sealers, drive belts and hammers in mills). These should be identified and spare parts kept in stock (Section 5). Processors can make an agreement in advance, possibly involving a small annual fee, to ensure that electricians or mechanics repair equipment as a priority.

Lack of maintenance is one of the most common problems that cause small-scale millers and bakers to lose money. Machine breakdowns arise from a number of different causes. They reduce productivity and increase production costs. Poorly maintained machines also produce substandard products and can contaminate products with metal fragments, as well as being a potential hazard to operators. Another common cause of failure is when those who operate or maintain a machine arbitrarily alter it. Proper maintenance ensures that machinery operates correctly and safely and prolongs its life, thus reducing capital and operating expenditure. To put preventive maintenance into practice, the following actions are needed:

- Identify priority machinery which have components that wear out more frequently
- Make a clear description of the procedures and standards for the work of machine operators and maintenance workers (such as lubricating, tightening bolts, adjustments etc.) In daily, weekly and monthly routine maintenance plans
- Organise a schedule and train staff to implement maintenance plans.
- Prepare a maintenance budget
- Record inspection results, analyse the records and evaluate the success of maintenance
- Continuously update procedures and standards.

NB: It is important to remove flour dust from equipment daily. A build-up of dust causes rust to develop and on electrical equipment it causes moving parts to jam. It can also seal the greasing points on machines and cause motors and engines to overheat and burn out or seize.

Staff

The numbers and types of workers needed to operate a cereal processing business depend on the amount of production and also on the degree of mechanisation of the process. Machinery that is used in labour-intensive parts of a process, such as filling and sealing machines, can significantly reduce the numbers of workers needed. However, a processor needs to carefully calculate the expenditure on labour and compare it with the cost of maintenance, spare parts and possibly loan repayments from buying the equipment.

It is possible to have all workers doing the same type of work throughout the day. When this type of staff organisation is used in a bakery, everyone prepares dough together then moves on to load a prover together and then all pack the products). However, it is often more efficient to allocate different jobs to each worker as the day progresses. It is also more flexible if each worker knows how to do all the jobs in a process so that they can cover for staff absences. An Activity Chart (Figure 3.2) can be used to decide the type of work that each worker does during the day.

Figure 3.2. Example of an activity chart used to plan work for bakery staff

Time	Supervisor	1st operator	2nd operator	3rd operator
6 am	Prepare ingredients for 1st batch	Prepare oven and help with 1st dough	Prepare 1st dough	Prepare 1st dough
7 am	Production records	Prepare 1st dough	Meal 30 minutes	
8 am	Prepare ingredients for 2nd batch of dough Meal 30 minutes	Tend ovens and help cut back 1st dough Meal 30 minutes	Cut back 1st dough	Prepare ingredients for 2nd batch of dough
9 am	Prepare ingredients for cake, scale 1st dough	Assist with 1st dough, attend ovens	Make 2nd dough	Make 2nd dough
10 am	Prepare mixer for cake batter and help mould 1st dough	Prepare oven for baking	Mould 1st dough, cut back 2nd dough	Mould 1st dough, cut back 2nd dough
11 am	Bake 1st batch	Bake 1st batch Meal 30 minutes	Make cake batter	Make cake batter
12 am	Remove 1st batch from oven, re-fire oven, scale 2nd dough, mould 2nd dough		Stack bread for cooling, mould 2nd dough, clean baking tins and equipment	
1 pm	Take products to retail outlets Meal 30 minutes	Bake 2nd batch	Bake cake Meal 30 minutes	
2pm	Prepare ingredients for biscuits and small-goods. Prepare dough		Stack cake and bread for cooling, clean baking tins and equipment	
3 pm	Bake buns and small goods, prepare ingredients for scones		Mould buns and small goods	Mould buns and small goods
4 pm	Bake scones small goods and buns		Clean bakery	
5 pm	Bake scones small goods and buns			
6pm	Prepare daily accounts	Take products to retail outlet	Prepare materials and equipment for next day	

Health and Safety

All processors have a responsibility to provide a safe and healthy working environment for their staff. The main dangers in milling are electric shocks and trapping fingers in belts or other moving machinery. Staff should be properly trained to use machines safely, particularly when cleaning them. Fail-safe devices such as electrical cut-out switches should operate properly and workers should not wear clothes or jewellery that could become tangled in moving equipment. Powered equipment such as mills and dehullers should always have guards in place over drive belts. Dust can also cause health hazards if inhaled. The most frequent causes of accidents in a mill include:

- Use of cables without insulation
- Lack of protective covers on switch gears, fuse-boxes etc.
- Use of un-earthed equipment
- Unauthorised additions to circuits resulting in overloading with the consequent risk of fire.
- Bridging over fuses
- Improper adjustment and maintenance of equipment
- Poorly aligned drive belts to machinery
- Poor maintenance or use of incorrect spare parts
- Use the incorrect tools for the machine.

Fires can be caused in flour mills by electric motors overheating and managers should ensure that a bucket of sand or an operational fire extinguisher is easily accessible. If an electrical fire occurs, the electricity should be turned off at the main switch and the fire smothered with a wet cloth or put out using sand. **DO NOT USE WATER!**

In bakeries, the main dangers involve heat and the risk of fires from ovens. Aprons or coats and heat resistant gloves should be provided and staff should be trained to handle hot foods safely. Fire extinguishers should be provided near to ovens. There are also dangers from mixers and a guard should cover the mixer and preferably have a working failsafe mechanism so that the mixer automatically stops if the guard is removed. Details of safe working practices are given in Table 3.3.

The machinery used in Uganda does not have fail-safe devices such as electrical cut-out switches. It is essential that motorised equipment is switched off before cleaning and maintenance.

Table 3.3 Basic rules for hygiene, sanitation and safety in cereal processing

Facilities required in the processing room
• A changing room where clothing and shoes that are not worn for work can be stored. • Separate hand-washing facilities for staff, with soap, clean water, nail brushes and clean towels. These should not be used for processing. • Toilets, which should be separated from the processing room by two doors or located in a nearby building. • First aid materials • Fire extinguisher/sand bucket • Protective aprons or coats washed regularly, hats/hairnets and if necessary, gloves and shoes. • Cleaning chemicals, stored away from the processing room.

Hygiene and sanitation
• Clean the processing room, toilets and washing facilities and storerooms every day. • Use the correct chemicals to clean equipment, make sure there are no food residues and rinse the equipment with clean water. • Make sure all cleaning cloths are washed and boiled each day. Do not hang them on equipment, products or window ledges to dry. • Do not leave dirty equipment until the end of the day before cleaning it. • Keep the area around the processing room clean and tidy, keep grass cut short. • Put all wastes into bins that are not used for anything else. Empty the bins periodically during the day away from the processing site. Clean up any spillages as they occur. • Prevent all animals from entering the processing area or storerooms. • Visitors should only enter the processing room wearing protective clothing and under supervision. • Wear clothing or jewellery that cannot get caught in machinery. • Wear a hat/hairnet that completely covers the hair. Do not comb your hair in a processing room or storeroom. • Cover all cuts, burns, sores and abrasions with a clean, waterproof dressing. • Do not smoke or eat chewing gum in any room where there is open food because bacteria can be transferred from the mouth to the food. • Do not spit in a processing room or storeroom. • Wash hands and wrists thoroughly with soap after using the toilet, eating, smoking, coughing, blowing your nose, combing your hair, handling waste food, rubbish or cleaning chemicals. Dry them on a clean towel before handling food again. • Keep fingernails cut short. • Do not wear perfume or nail varnish as these can contaminate products. • Do not handle any food if you have sores, boils, septic spots, a bad cold, sore throat or a stomach upset. Report any of these to the manager and do alternative work. • Do not cough or sneeze over food. • Keep food covered wherever possible. • Keep all food, tools and equipment off the floor. • Keep ingredients in sealed containers. • Do not use broken or dirty equipment. • Report any signs of insects, rodents or birds to the manager.

Safe working

- Do not use a damp cloth to carry hot baking trays or pans.
- Wear shoes that protect your feet from falling or hot objects.
- Cover burning electrical equipment or cooking oil with a damp cloth or sand. Never use water to put out flames.
- Shield gas burners from direct sunlight because the flames can become invisible.
- Do not carry large containers of hot food on your own, get assistance.
- Do not put cleaning fluids into old food containers.
- Do not allow customers, children, visitors or animals into the mill or bakery building. Ensure that only trained staff enter the premises or operate machines.
- Prevent staff wearing any loose clothing that could become caught in running machines. Provide them with overalls.
- Do not allow staff to start a machine unless they know how to stop it. Only one person should operate a machine at any one time.
- Make the layout of machinery logical and leave sufficient space around it so that there are few chances for operators to get in each other's way.
- Do not try to attract operators' attention by touching or calling them from behind if they are using a machine. Always speak to them from the front, or wait until they have finished what they are doing.
- Train staff to be familiar with potential hazards (e.g. potentially dangerous machines or hot surfaces) and what they should do in case of an accident. Use charts hung on the wall near to each machine to show safety precautions
- Ensure that guards are fitted and in place over any moving parts of a machine and alert staff to machines that appear to be standing still when running at high speed
- Never allow staff to clean, adjust or lean over moving machinery and do not allow them to leave a running machine un-attended
- Encourage operators to report any loose parts on a machine
- Do not allow staff to work with equipment that is defective. Put a note on any machine that is under repair saying 'DO NOT TOUCH'
- Do not allow anyone to touch inside electric equipment while it is connected
- Regularly check the cords of electrical appliances to ensure that outside covers are not broken and wires are not exposed.
- Prevent staff from running inside a building. Immediately clean up any water, oil or grease on the floor using sawdust, sand, husks etc.
- Ensure that staff that work in dusty conditions protect their mouth and nose with a mask. Clean the building each day.
- Have a first aid box containing sterilised dressings, cotton wool, adhesive plasters and bandages.

(Adapted from: The Food Hygiene Handbook, by Sprenger, 1996 and Opportunities in Milling & Baking, Fellows & Axtell, 2003)

Record keeping

There are four sets of records that should be kept by the owner of a small cereal processing unit (Table 3.4). Keeping records is an investment of time and money and this must be related to the scale and profitability of the business (the benefits must outweigh the costs.

Records must be used for them to have any value.

This means that the processor must understand why the information is collected and what it can be used for. Processors should also put in place a system of checks to ensure that one person does not have responsibility for a whole area of record keeping. For example the person who keeps records of ingredient purchases should be different to the person who records levels of stocks and manages the storeroom.

Table 3.4. Types of records for a small-scale cereal processing business

Type of record	Information to be recorded
Production records	Recipes (bakery) Raw materials or ingredients received and suppliers' details Wastage % at different stages of the process Stock levels for each raw material and ingredient Production volumes and measurements Maintenance routines, details of spare parts kept in stock
Quality assurance records	Target amounts of ingredients and any changes made to recipe Measurements made at process control points Batch numbers and product code numbers Cleaning standards and schedules
Sales records	Names of customers and amounts sold to each Weekly and monthly sales volumes
Financial records	Income from sales Costs of all process inputs Staff records Cash flow Profit/loss Tax records Bank statements

(Source: Fellows, P., Midway Technology Ltd., Bonsall, UK)

Productivity improvement

Productivity can be improved by:

- Improved efficiency (e.g. lowering operating costs, savings in idle machine time and reducing waste)
- Better procedures for buying materials
- Improved decision making and communication
- Higher performance by minimising equipment breakdowns, reducing other causes of lost time
- Improved organisation, better staff morale and co-operation.

Improved process efficiency can be achieved by increasing the output of a processing plant without additional investment. To measure this an entrepreneur must calculate how much money it costs to produce one unit. If more units are produced at the same cost or within the same time frame without affecting quality, then productivity is increased. Productivity can also be improved by changing the product design or layout of the production facilities, changing raw materials suppliers or work organisation.

Improving efficiency in a process involves reducing wastage of time, materials and space, or unnecessary movement of foods, staff or equipment. Motivated staff will go a long way to increasing efficiency by reducing wastage. The layout of a production unit is another factor that can affect efficiency. When deciding where to fix permanent machinery, care should be taken to plan the layout to allow for a flow of product through the process, sufficient space to avoid congestion and to ensure safe operations (Chapter 3, Section 3.2).

Avoiding waste

Ideally all bakery products that have a short shelf-life should be sold on the day of production when they are at their freshest. This maximises the income and avoids wastage which has a serious effect on profitability. However, unsold products are still edible for a few days provided that they are stored correctly. They can be used for a variety of other purposes to generate an income and avoid wastage.

Ideas that can both reduce energy consumption and save processors money include:

- Switching off lights and electrical equipment when they are not being used
- Solar water heating (e.g. for pre-heating process water or washing equipment)
- Building in the flexibility to use alternative energy sources when installing new bakery ovens so that they can use the most environmentally suitable fuels
- Use local briquette makers rather than using fuel-wood
- Use local suppliers of raw materials that can be delivered by bicycle, rather than using a vehicle to collect them. Similarly, make as few journeys as possible to deliver products to wholesalers or retailers.

Checklist 3

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.

Question	Tick	Notes
1. Do you know how to calculate your production rate?		
2. Dou you know how to calculate the amounts and true costs of materials required for a given production rate?		
3. Do you know how to calculate the yield of product and levels of wastage?		
4. Do you know how to plan labour requirements and how to allocate jobs to different workers to maximise efficiency?		
5. Can you calculate the size of equipment required using product throughput?		
6. Do you have correct maintenance procedures for your equipment?		
7. Have you developed safety training and checked the process to ensure that equipment and procedures are safe?		
8. Do you keep adequate records?		

4 Products and Production Methods - Cereals and Flours

The purposes of this manual are both to improve production of existing products and to stimulate ideas for new products that may have a demand and can be produced at a small scale. However, there is a wide range of cereal flours and bakery products that are produced in Uganda and it is not possible in a manual of this type to describe them all in detail. Products are therefore grouped together and described in categories.

The high demand for flours and bakery products, especially in urban areas of Uganda, has led to strong competition as more and more people start to produce these products. Processors should therefore aim to diversify and produce new types of processed cereal products described in the tables below. Each table describes the process stage on the left and has notes on processing conditions, equipment and quality assurance checks on the right. Further details of quality assurance checks are given in Section 6.

Whole grains and pulses

Cleaning and packing dried whole grains and pulses can be profitable business. The costs of labour for cleaning and packing, plus the cost of the packaging materials, result in a higher price for the products compared to similar products that are sold loose in markets. The selling points to attract customers are a safe, high quality product (free from contaminants) and a guaranteed weight in the pack. Promotional information can emphasise for example that products are produced hygienically and are guaranteed free from dirt or stones, mould, insects and other contaminants.

Rice parboiling is not currently practised in Uganda, but it can be used to improve the quality and yield of rice grains. The process also loosens the bran layer and toughens the grain, which reduces breakage, increases hulling efficiency and capacity and extends the life of machine components. However, it also changes the colour and flavour of rice and because this product would be new to Ugandan consumers, processors should test it with potential customers to find out if the changes are acceptable.

Table 4.1 Process for dried grains

Stage In Process		Notes
Essential	**Optional**	
Grain		Harvest and store
	Wash/dry	Use wash tanks with clean water to remove stones, leaves, pesticide residues or soil. Wastewater is extremely dirty and must be disposed of in accordance with local pollution standards. Dry the grain if the moisture content is too high (Table 4.11).
Sort/ grade		Pick out spoiled or mouldy grains, stones, leaves etc. by hand or use a seed cleaner
	Parboil	In boiling water for 4-48 hours.
	Dry	To 12-15% moisture depending on the grain (Table 4.11). The time needed for drying depends on the temperature, humidity and speed of the air and the type of dryer. Check for mould growth, insect contamination and the temperature and time of drying.
Pack		Using an electric sack stitcher to seal paper bags or a heat sealer to seal plastic bags. Check fill-weight and seal.
Label		Check that label is correct for type of product and properly aligned.
Store		Store in a cool dry place away from sunlight.

Ugandan Maize Flour

Flours

The process for making flour from maize, rice, millet or sorghum is described in Table 4.2.

Table 4.2 Process for flour

Essential	Optional	Notes
Grain		Harvest and store
↓	Wash/dry	Use wash tanks with clean water to remove stones, leaves, pesticide residues or soil. Wastewater is extremely dirty and must be disposed of in accordance with local pollution standards. Dry the grain if the moisture content is too high (Table 4.11).
Sort/ grade		Pick out spoiled or mouldy grains, stones, leaves, etc. by hand or use a seed cleaner
Dehull		Remove bran using a dehullers
Mill		To the required particle size
Pack		Fill flour manually or using a bag filler. Seal paper bags with an electric sack stitcher or seal plastic bags with a heat sealer. Check fill-weight.
Label		Check that label is correct for type of product and properly aligned.
Store		Store in a cool dry place away from sunlight.

Combinations of grains

Most millers concentrate on one type of cereal flour as their main business. If the demand exists, flours can be made from mixtures of dehulled grains and legumes or mixed flours for specialist markets, using the same equipment and having the same brand name. Examples include weaning food mixes, pre-prepared breakfast cereal mixtures, or specialist flours for people suffering from diabetes or intolerance to wheat gluten (Coeliac disease).

If composite flour for infant weaning foods is considered (Table 4.3), a miller must ensure that it contains sufficient energy, protein, minerals and vitamins and that the balance of nutrients is adequate for a child's healthy growth and development. Some legumes also contain anti-nutritional substances that must be destroyed by heating.

It is essential that millers seek professional advice to ensure that the combination of nutrients is adequate and balanced for a child's healthy growth and development.

Nutritionists at Makerere University Department of Food Science and Technology, one of the specialist international development agencies (Annex A) or the Ministry of Health should be consulted before producing weaning foods. Any new weaning food must also be tested by the Uganda National Bureau of Standards and Ministry of Health to ensure that it is safe to eat (it should not contain any micro-organisms or anti-nutritional factors that could make a child ill). New products must also meet national nutritional and fortification standards.

Another method of producing weaning foods is to use an extruder, but the cost is likely to be beyond the reach of many small-scale millers and the market for these products is already dominated by Africa Basic Foods in Kampala. Details of extrusion are therefore not included in this manual.

Table 4.3 Process for weaning flour mix

Stage In Process		Notes
Essential	**Optional**	
Grain		Harvest and store
↓	← Wash	Use wash tanks with clean water to remove stones, leaves, pesticide residues or soil. Wastewater is extremely dirty and must be disposed of in accordance with local pollution standards. Dry the grain if the moisture content is too high. See Table 4.11.
Sort/ grade ↓		Pick out spoiled or mouldy grains, stones, leaves, etc. by hand or use a seed cleaner.
Dehull		Remove bran using a dehuller.
↓		
↓	← Toast	For some, toasting cereals and/or pulses for 5-15 minutes at 180-200°C to remove anti-nutritional factors and increase their digestibility.
Mix		Weigh the correct combination of raw materials (see text).
↓	← Mix	For some, blending in a vitamin-mineral premix.
Mill ↓		To the required particle size.
Pack ↓		Fill flour manually or using a bag filler. Seal paper bags with an electric sack stitcher or seal plastic bags with a heat sealer. Check fill-weight.
Label ↓		Check that label is correct for type of product.
Store		Store in a cool dry place away from sunlight.

Milling equipment

For efficient production and high productivity, the capacity of each piece of equipment in a process should match the others. This prevents money being wasted on equipment that is larger than necessary, or creating ‘bottlenecks’ caused by one piece of equipment that is too small. For example, the output of a seed cleaner should match that of the dehuller and the maize mill.

The equipment that is required in a small flour mill is shown in Table 4.4. The main items are a seed cleaner, a dehuller, a mill and packaging equipment and these are described in more detail below. The design and construction of feed hoppers, dehullers, mills and other equipment should allow free passage of grains or flour without any recesses that could trap food and lead to contamination. Careful design and construction also prevent the release of dust from equipment. Most milling equipment is made from mild steel and it is important that welding is done to a high standard, without holes in the weld or small projections that could trap food. All welds should be ground to a smooth finish. Mild steel easily rusts and it is important that equipment is kept dry to prevent rust from contaminating the grain or flour. A mill or dehuller should be easy to dismantle for cleaning and maintenance. Nuts and bolts that are routinely removed should be made from high quality steel so that threads do not wear out quickly. Worn bolts have the potential to fail and damage a mill or dehuller and injure an operator and metal fragments contaminate the flour.

Wherever possible, it is better to buy equipment from local suppliers or engineering workshops because it should be faster and easier to have machines serviced or to obtain spare parts. Information on equipment suppliers is given in the UNIDO Food Processing Equipment Directory. If equipment must be imported, the following points should be considered when ordering it:

- Say exactly what is required (manufacturers may have a range of similar machines).
- Give the throughput required in kg or litres per hour and the type of food to be processed
- Where possible, give other information (model number of machine, single or three-phase power, number and types of spare parts required).

Information on overseas equipment suppliers is available at USSIA, UNIDO, UMA, at offices of development agencies, the Chamber of Commerce, Makerere Department of Food Science and Technology, UIRI (Annex A), or at embassies of exporting countries. Internet access can also be used to locate websites of equipment manufacturers.

The equipment required for milling is as follows:

Table 4.4 Equipment for milling

Type of equipment	Spare parts	Maintenance required	Cleaning
Bagging equipment	None	See Section 4.4.1	Daily cleaning with a brush to remove flour dust or contaminants
Conditioners	None	None	Periodic draining and cleaning
Cyclone separators	None	None	Daily cleaning with a brush to remove flour dust or contaminants
Diesel engines	V-belts	See Section Diesel engines	Daily cleaning with a brush to remove flour dust or contaminants
Dryers	Plastic covers, preferably UV resistant	Annual replacement of polythene covers, or every 3-5 years for polyester	Clean trays after use with detergent and clean water
Maize dehullers	V-belts	Check belt tension and tightness of bolts	Daily cleaning with a brush to remove flour dust or contaminants
Maize shellers	V-belts	Check belt tension and tightness of bolts	Daily cleaning with a brush to remove flour dust or contaminants
Mills	V-belts	Check belt tension and tightness of bolts	Daily cleaning with a brush to remove flour dust or contaminants
Rice dehullers	V-belts	Check belt tension and tightness of bolts	Daily cleaning with a brush to remove flour dust or contaminants
Seed cleaners/ Winnowers	V-belts	Check belt tension and tightness of bolts	Daily cleaning with a brush to remove flour dust or contaminants.

Bagging equipment

Flours are filled and sealed into paper or polythene bags for retail sale, or into polypropylene, multi-wall paper or cotton sacks for bulk sales. Most small millers fill bags and sacks by hand and then check the filled weight on scales, but this is time-consuming. Faster filling can be achieved using a manual or semi-automatic bagging machine (Fig. 4.1), which is adjustable for different fill-weights. Flour is released from a hopper into a weighing section and the correct weight is then dropped into a bag or sack.

An auger carries flour from the mill to the weighing/bagging machine. It is important that this is set up correctly because the product feed rate of the auger affects the accuracy of the weighing/bagging machine. Two bolts join sections of auger and it is important that the spring washers are in lace and the bolts are fully tightened (a loose bolt can severely damage the auger). All connecting sleeves should be fully tightened to prevent the auger sagging (if this happens the auger will cut through the outer tube and destroy it). Guards should be fitted over all drive belts. A starter should be used for the conveyor motor and located on a wall, not on the auger or motor. Never wire a motor directly to a socket. Wiring should be an adequate size to prevent a voltage drop. A competent electrician should set the overloads o match the rated current of the motor and check that it rotates in the correct direction.

Fig. 4.1 Bagging machine

If it is necessary to service the auger or remove a blockage, make sure that the motor is isolated and that all guards are replaced before reconnecting the power supply.

To operate the auger, switch on the motor and feed material into the intake end. If material does not flow evenly from the discharge end, check that:

- The motor is turning in the correct direction
- The auger is turning
- V-belts and chains are tightened
- Extensions are properly connected
- The auger turns freely in the tube
- Material is not bridging over the inlet
- An obstruction has not entered the auger tube
- The outlet spout is not obstructed by product (this will lead to a build-up of material in the tube which will damage the top of the auger)
- Flour is not damp as this could build up on the inside of the tube, reducing the clearance with the auger and eventually causing it to stall. Remove the auger and clean the tube.

The auger should not be run empty as this will cause severe wear on the intake end and between the auger and the tube – causing the auger to cut through the tube.

REMEMBER
You are only issued with one set of fingers. An auger can remove them with great efficiency and they are not replaceable!

The bag filling and weighing machine should be set up on a level floor and made exactly horizontal using the adjusters on the legs of the machine (the slope in any direction should not exceed 2^{o}). A flexible connection should be made between the feed auger and the inlet. It is important to ensure that all linkages and push rods on the machine are able to move freely and is not obstructed by anything.

The machine can weigh out and fill bags in the range of 2 – 10 kg (the range is stamped on weigh beams within the machine casing). To set the exact filling weight, locate the front edge of the large sliding weight to the required position and lock it. Two bags are then positioned beneath the fillers and the bag supports are adjusted so that the bags fit properly on the supports while they are being filled. A continuous and even feed rate to the filler is needed to achieve accurate fill-weights. Once this is set, the rate should not be changed without recalibrating the filler. Under no circumstances, should the machine be over-fed with product or there will be a build-up of flour in the diverter chute and bagging boxes.

Fill and check-weigh six bags from each side of the machine, discarded the first bag to be filled from each filling head. If needed, adjust the target weight using the coarse and then fine weight adjusters. The coarse adjuster has a range of ±750g in 250g divisions. The fine and very fine adjusters are on a screwed rod that has an overall range of 700g front to back. One turn of the fine weight adjuster will alter the fill weight by 5g and one turn of the very fine adjuster will alter it by 1g. Each adjuster should be locked into position when the correct weight has been set. With all adjusters, movement to the front of the machine reduces the fill weight and movement to the back of the machine increases the fill weight. Each side of the filling machine should be treated independently.

Any variation in the feed rate or bulk density of the flour requires the fill weight to be adjusted.

Worked example 9: Fill weight adjustment
Check-weighing show bags of flour to be 5250g compared to a target weight of 5kg. Adjust the coarse adjuster towards the front of the machine by one 250g division on the bar. Tests show that this gives a fill weight of 4980g. Use the fine adjuster and give 4 turns towards the back of the machine. The correct fill-weight of 5000g is now achieved and is set by locking the weights.

Maintenance

Ensure that counterbalanced weighing mechanisms are free to move up and down and the pushrods are free to move. Bearings are sealed and do not require lubrication. If metal bearings are fitted at the top of the pushrods, they should be lightly lubricated occasionally. It is essential to keep the machine clean of flour dust, especially on support trays, weighbeams and within the machine, otherwise inaccurate fill-weights may be produced. Regularly check dust gaiters on the bag clamp rubbers and replace them before they are worn out.

Any inaccuracies in weighing are likely to be due to one of the following causes:

- Movement of pushrods is restricted
- Product feed is not directed at the centre of diverter chute
- Product build-up on diverter chute because feed rate is too high
- Incorrect position of adjusting weights
- Variations in product feed rate

Polythene bags are heat-sealed. Paper bags and all types of sacks can be sealed using an electric sack stitcher (Fig. 4.11).

REMEMBER
Do-it-yourself electrical wiring can kill you.
Get a professional electrician for all electrical work!

Conditioners

Moistening maize before milling helps to loosen the seed coat and ensures that the grain has the optimum moisture content for milling (Table 4.11). A simple wash tank is sufficient and the maize is simply wetted and then removed for hulling.

Cyclone separators

Fig. 4.2 Cyclone separator

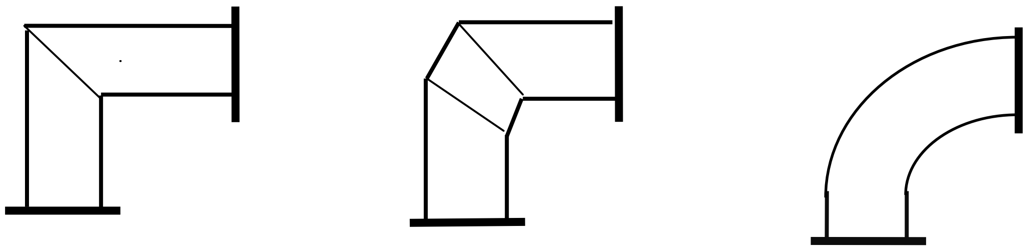
A fan sucks flour from the mill through the screen and transports it to a cyclone separator. In the cyclone, flour rotates around inside in a spiral action and is separated from the air, causing it to drop into a collection bag underneath. The air escapes via a vent pipe at the top of the cyclone, preferably to the outside of the building.

It is important to design the cyclone separator correctly to avoid losing product into the air. The inlet pipe must enter the cyclone tangentially and the outlet (vent) pipe should be three times the area of the inlet pipe.

The better the fan suction, the quicker the flour can be removed from the mill. The amount of suction depends on the following factors

- The diameter of the air intake (it should be one third of the fan diameter. If it is smaller, insufficient air is drawn in and if it is larger air leaks from the edge of the fan intake).
- smooth corners to ducting and pipes (Fig. 4.3)
- sealed joints to reduce air leakage on the suction side and prevent air blowing out with loss of flour on the pressure side.

Figure 4.3 Bend designs in pipework for conveying flour from a mill (P. Tibasiimwa)



Poor design Better design Best design

Diesel engines

Fig. 4.4 Diesel engine

The engines are water-cooled with an attached fuel tank. They turn clockwise when looking at the flywheel with the exhaust on the left side. The speed of the engine is controlled by a governor and **should not be increased.**

Before starting for the 1st time or after an overhaul

- Remove the crankcase door and fill troughs under connecting rods with oil
- Apply oil to each oil hole on top of big end bearing
- Open oil filler and fill engine sump with oil to 1 cm from top of filler
- Operate lubricating oil pump by hand (or rotate the engine using the starting handle) until oil flows down over the main bearings and into the dipper troughs
- Close crankcase and fill recesses in cylinder head with oil for valve lubrication
- Fill cups in pushrods and tappet heads with oil
- Remove brass plug near tappets (marked 'oil') and pour in 0.25 litres of oil
- Fill rocker shaft greasers and give several turns to lubricate valve rockers.

To start the engine by hand

- Check oil level, fuel level and coolant level before starting the engine
- Prime fuel system (1st time started)
- Swing valve lifter under tappets
- Screw in tightly the compression changeover valve on cylinder head
- Disengage governor hand lever by pushing it downwards and trip the overload pawl on the fuel pump
- Place starting handle on the crankshaft extension and turn
- Disengage the exhaust valve lifter as quickly as possible and lock it in the 'off' position (the engine should fire as soon as one valve has been released)
- Remove starting handle
- Check oil indicator plug to ensure that the oil pump is working
- Check that coolant is circulating
- Apply load as soon as the engine reaches full speed
- For 1/3 load, keep compression changeover valve screwed in. For more than 1/3 load, open valve as far as it will go.

Engine maintenance

Time spent on proper maintenance will save costly repairs and lost time.

Table 4.5 – Recommended maintenance schedule

Daily	• Check levels of fuel, water and lubricating oil • Check oil around valve stems and in push rods • Turn grease cups • Check water temperature • Check exhaust smoke
Every 100 hours	• Clean air filters • Check tightness of all nuts
Every 250 hours	• Apply a drop of oil to governor linkage and fuel pump side window • Check drive belt and fan • Drain moisture trap in exhaust pipe • Remove fuel injectors and check fuel spray
Every 500 hours	• Clean compression valve screw and fuel filter • Change engine oil • Adjust valve clearance • Check lubricating oil strain
Every 1000 hours	• Decarbonise engine • Grind in valves • Check piston clearance if gasket is changed • Clean out inlet manifold and exhaust pipe • Check water jacket for scale • Check the governor linkage is free to move • Renew fuel filter • Check injector nozzles for wear • Check big end and main bearings.

Dryers

Each type of grains has an optimum moisture content for milling (Table 4.11a) and a common problem is that grain is too wet because farmers have inadequately dried it. Millers may therefore have a dryer to reduce the moisture level before milling. This can be a simple solar dryer or less commonly a fuel-fired dryer. Details of drying equipment are given in references in the bibliography. Details of procedures and equipment to measure the moisture content of grains are given in Section 4.3.1. The plastic covers on solar dryers should be replaced each year if they are made from polythene, or every 3 years if they are made from polyester. Dryer trays should be washed with detergent, rinsed and sun-dried before re-use.

Maize and rice dehullers

A number of designs of rice dehuller are widely used. The ‘Japanese rubber roller’ type (Fig. 4.5) rubber rollers that are moving at different speeds press paddy grains and the shearing action removes the husks (Fig.4.6). These machines are made in several forms. A single-roller type removes the hulls to produce brown rice and a second section is needed to ‘whiten’ brown rice by removing the bran. Alternatively, these sections may be combined in a single-pass machine. These dehullers cause less breakage of the grain and are less likely to be damaged by stones in the grain or by unskilled operators.

Fig .4.5 Rubber roller rice dehuller

The ‘Engelberg’ type dehuller has a rotating horizontal steel cylinder contained in a chamber. The lower half of the chamber has a slotted screen and an adjustable blade to control the friction on the grain. A valve at the grain discharge controls the pressure on the grain. In operation the grain enters the chamber and friction caused by ridges on the cylinder removes the hulls. The second part of the cylinder then removes the germ and bran. The steel rollers of the Engelberg type both remove the husk and polish the rice. The dehuller is robust and requires less maintenance, lasting for 20-40 years depending on its use. Spare V-belts should be kept and checks made weekly on belt tension and the tightness of all bolts. Dehullers should be brushed clean each day.

Fig.4.6 Engelberg type maize dehuller

Maize shellers

The machines supplied by UNIDO have a diesel engine fitted and the maintenance procedures described in Section 4.4.4 should be followed. Maize shellers cause considerable dust and should be located in an area where dust can be prevented from contaminating other equipment or products. Dust can also be explosive and is a known risk. The machines should be cleaned daily by brushing out dust and shells.

Fig 4.10 Maize sheller

Mills

Hammer mills predominate in Uganda and other types of mills are not commonly found. The mills originate from a wide variety of countries and this is a problem when spare parts are required. All hammer mills have a chamber that is lined with a toughened steel beater bars (or a 'breaker plate') with an interchangeable screen at the base. A high-speed rotor inside the chamber is fitted with swinging hammers made from hardened steel, which hit the grain at high speed and throw it against the beater bars. The grain then bounces back into the path of the hammers and is disintegrated. The fineness of the flour is controlled by the size of the holes in the screen (smaller holes produce finer flour). If a screen with larger holes is used, the hammers produce fine particles, but larger particles also pass through the screen to produce coarser and darker flour.

The size of holes in the screen also determines the output from the mill (larger holes give a higher output).

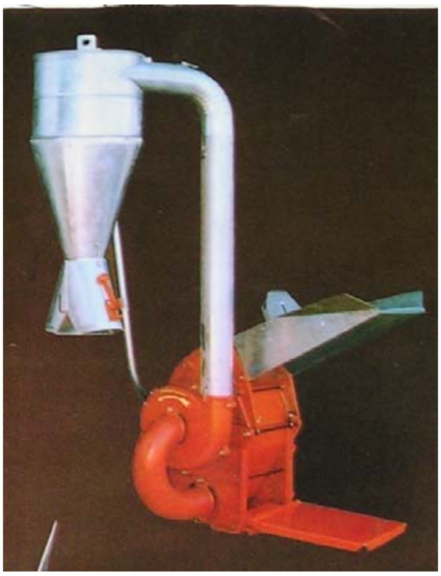


Fig.4.7 Hammer mill

The following details of maintenance of mills were provided by Patrick Tibasiimwa and were first published in 'Opportunities in Milling and Baking', by P. Fellows and B. Axtell, CTA, 2003 (Annex A). A summary of maintenance requirements is given in Table 4.5.

Table 4.6 Details of routine mill maintenance schedule

Daily Maintenance	**Mechanical** • check and grease bearings, replace if faulty • check pulley wheels for cracks and replace to avoid damaging belts. • check bolts and nuts for tightness. • check the oil level in diesel engines and top up with the correct oil if required.
	Electrical • clean flour dust off motors and other electrical equipment • when a machine is not in use, make sure that power is switched off at the mains and that equipment has not been left switched on. This is very important when power cuts occur, because when power returns a machine that has been left on can injure an operator or cause a fire.
	Housekeeping • store tools and equipment in pre-determined places to help find them next time and to help notice when they have gone missing. • always keep walkways clear of tools and equipment • clean diesel engine cooling fins every day to prevent dust settling and causing the engine to overheat and eventually seize • when re-fuelling diesel engines, pour the fuel through a filter to prevent rust deposits in the fuel drum getting mixed with the fuel and damaging the engine • clean the machinery and floor
Weekly maintenance	• check hammers for wear and replace if necessary • check the shaft (especially if locally manufactured machines are not tested for strength or alignment) • check that locking nuts on the shaft are tight. • check that fan bolts have not loosened as the fan then becomes very dangerous. • check the bearing mountings as this area is prone to cracking • check the engine oil and oil filter on diesel engines and change them every 160 working hours. Change the fuel filter every 320 working hours.
Monthly maintenance	• check the body casting and welds for cracks • tighten floor nuts and look for any cracks in the mill foundation • check the fan key and make sure that the fan is a slide fit on the shaft for easy removal. If the blades are worn always replace with the correct thickness of steel and then check for balance • check that cables are secured and there is no sign of insulation breakdown • check the acid level in batteries that are used to start diesel engines. Keep the terminals clean.

If a hammer mill fails to grind efficiently the hammers may be badly worn and they should be first turned around to use the second edge (Fig. 4.8). When this has worn the hammers should be replaced. Hammers should also be checked for elongation of the fixing holes and worn pins. If the holes are worn it can cause the hammer to hit the screen and damage it. If worn pins are not replaced, they eventually fail causing the hammer to fly off and cause considerable damage to the screen and other parts inside the mill.

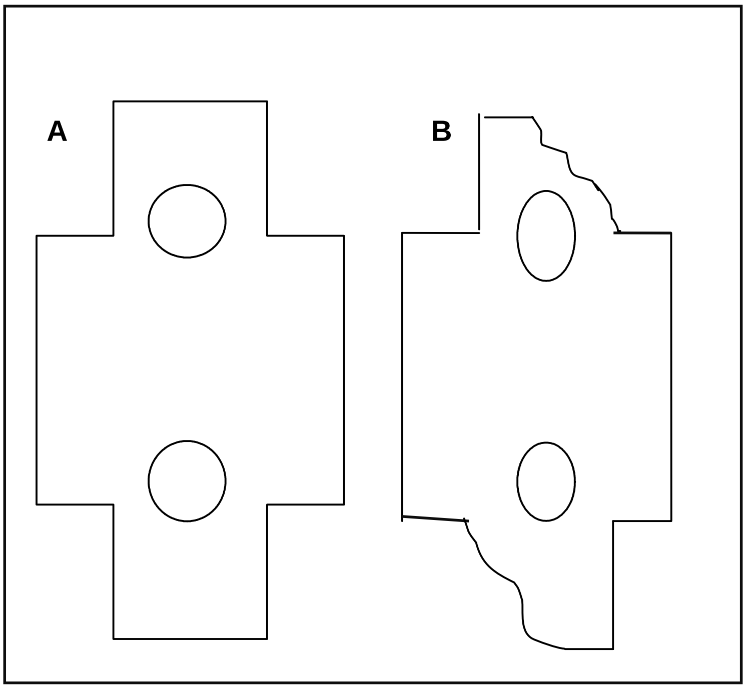


Fig. 4.8   A) New hammer and B) Worn hammer from a hammer mill. (P.Tibasiimwa)

When fitting new hammers ensure that they are the same length and the holes are in the same position as the old ones. Hammers should also be checked to ensure that they are the same weight and are balanced in matching pairs so that the machine runs smoothly without vibration. A simple balance can be made for checking the weight of pairs of hammers (Fig 4.9).

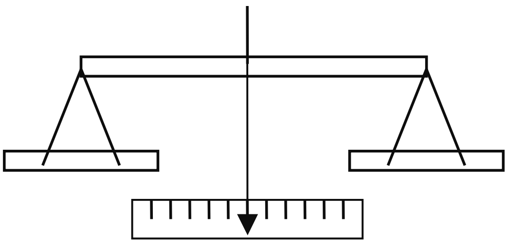


Fig. 4.9. Balance to check the weight of hammers
(Note: The pointer should hang vertically when there are no hammers on the balance.)

If a hammer mill continues to vibrate after the hammers and bearings have been checked, make sure that the distances from the spindle to each hammer pin hole are equal. If they are not equal, they must be corrected by filling the holes with welding and re-drilling them. The rotor must then be re-balanced. A simple method to balance the rotor is to use two angle bars set on the edge of two benches. The angle bars must be straight and set level with a spirit level. The pulley, bearings, keys, hammer pins and fan should be removed from the shaft before balancing. The rotor is rolled along the angle bars and where it stops the top is marked with chalk. The heaviest part is always underneath when the rotor stops moving. The procedure is repeated several times and the chalk marks are checked for closeness to indicate consistent results. Dropping welding onto the outer edge then increases the weight of the rotor at the top.

Alignment of pulleys and V-belts

Mills and dehullers are usually driven by belts that connect the motor to the mill. These come in five sizes (A – E), but 'B-section' or 'C-section' belts are most commonly used on small mills or dehullers (Table 4.6). Pulleys and belts should be as short as possible and fully covered with guards. It is important that drive pulleys and V-belts are exactly aligned, in order to reduce wear on the belts and to transmit maximum power to the machine. It is the sides of V-belts (not the bottom) that lock into the pulley and grip it. To achieve maximum belt life and power transmission, the pulleys must be exactly at 90^{o} to the belts and the belts must fit correctly into the pulley grooves. V-belts are tensioned to drive the mill and when measured at the centre of the belt span, there should be a 16mm deflection per metre of belt (measured from a straight edge placed across the pulleys). Tensioning increases the load on the bearings of both the mill and the motor. If a belt heats up there is a problem with the tension and it is therefore essential that belts be tensioned to the correct amount. Dust is one of the main causes of damage to V-belts and they should therefore be cleaned daily.

Table 4.7 Number of belts for mills of different power requirements

Power of mill motor (HP)	'B' Section belt	Power of mill motor (HP)	'C' Section belt
0-7	1 belt	0-9	1 belt
7-14	2 belts	9-18	2 belts
14-21	3 belts	18-27	3 belts
21-28	4 belts	27- 36	4 belts

(HP = Horsepower, 1HP = 0.745 KW. Minimum 'B' pulley diameter 115mm, Minimum 'C' Pulley diameter 175mm)

Checking the operation of a mill

The correct quality of grain is important to reduce the operating costs of the mill. Properly dried and cleaned grain mills faster, requires less energy (hence lower power costs), creates less wear on the mill and dehuller and so reduces maintenance costs. The efficiency of the mill depends upon the following factors:

- distance from screen to hammers
- speed of rotor
- suction of fan
- flow of flour from the mill to cyclone
- correct design of cyclone to minimise flour losses.

Distance from screen to hammers

The distance between the hammers and the screen should be as small as possible. If there is a large gap, little or no flour will pass through and the output of the mill is reduced. Hammers should be 4-6 mm from the casing. If the gap is larger, power is wasted because flour will build up on the screen, giving a lower output and greater wear on both hammer and rotor plates. Wider hammers have slightly better efficiency than thin hammers.

Speed of rotor

The speed of rotation is critical for efficient operation of the mill and 80 meters per second is the optimum speed for the hammer to strike grains. The optimum mill speed can be found using Table 4.7 by measuring the distance between the furthest points on the hammers when assembled on the rotor with the hammers at their maximum extension. Alternatively, the speed of the rotor can be calculated from the motor speed use the following formula:

$$\text{Rotor speed (rpm)} = \frac{\text{Motor pulley diameter (mm)} \times \text{Motor speed (rpm)}}{\text{Mill pulley diameter (mm)}}$$

Table 4.8 Optimum rotor speeds for different sized hammers in a hammer mill

Distance of hammers (mm)	Optimum Speed of rotor (rpm)	Distance of hammers (mm)	Optimum Speed of rotor (rpm)
300	5100	525	2910
325	4700	550	2780
350	4365	575	2660
375	4075	600	2550
400	3800	625	2440
425	3600	650	2350
450	3400	675	2260
475	3220	700	2180
500	3060		

(Note: An allowance of plus or minus 15 % can be made on these figures).

Fault finding

During operation of the mill, stop and investigate immediately if anything unusual is noticed with the mill or its performance, for example:

- vibration
- excessive heating of bearings, pulleys or belts
- unusual noises
- loose nuts and bolts
- damp grain causing a blockage.

In order to solve a problem it is necessary to first identify the real cause. For example if a blown fuse is the problem, but bare wires touching the roof is the real cause, no matter how many times you replace the fuse it will not stop the wires touching on the roof. Some examples of faults in a hammer mill and possible causes are given in Table 4.8. Similar considerations apply to other types of milling equipment.

Table 4.9 Checking for faults in milling equipment

Fault	Check
Motor stops running	• if power is there at the correct voltage • for a burned smell from motor • for burning of electrical cables • if the isolation system is working (have fuses blown?) • if the motor can run without the mill • where there is more than one machine, check the other to see if it is working • if neighbours' machines are working
Motor running but blows fuse	• that the load is below the rated load. • if the fuse is the correct size • insulation resistance of cables and motor windings
Motor running but blows fuse when under load	• if motor is overloaded • for correct feed rate of grain into the mill • if connections on the motor are satisfactory • that the fuse rating is correct
Motor develops unusual noise	• for loose fan cover on the motor • for worn bearings • starter • power supply (are all phases operating?) • for loose connections at main switches
Motor smoking	• if varnish on motor windings is intact • for worn bearings • starter • for loose connections • for burnt out motor
Motor over-heating	• bearings or starter • for correct loading on the motor • motor wiring • motor rating • if fan is working • maintenance book (is motor due for service?) • power supply • that alignment of pulleys/belts is correct • grease (is the quantity and quality correct?)
Vibration of the mill	• if bearings are worn • if there is a loose fan, rotor or pulley • if shaft has bent • if hammers are unbalanced, loose, broken or wrong type • for wrong type of bearings
Bearings overheating	• that bearing grease is correct type and quantity • for bearing alignment • the load on the rotor • that bearings are the right type
Overheating belts	• for incorrect pulley size or depth of v-belt • for over tensioned belts • if belts have become misaligned • that pulley diameter is not too small • that there are not too few belts to drive the mill
Unusual noise	• if hammers are hitting screen or casing • for broken hammer pins

	• for foreign object inside mill

Sack stitchers

The machines sew paper or thick (minimum 120µ) polythene sacks to seal them. **The mechanism will carry the sack through the machine and it should not be pulled or pushed.** There should be sufficient free space between the top of the product in the bag and the sewing line to have enough material to sew. A minimum of 5 cm is needed for paper bags and 10 cm for jute or netting bags.

Fig. 4.11 Sack stitcher

Do not change the settings of internal components – these are set at the factory and changing them could damage the machine

Use of the stitcher:

1. Form a gusset in the top of the bag/sack. Fold the top over as close as possible to the product and then bring it to a vertical position for sewing
2. Take the top right side of the bag in the left hand and feed it between the presser foot and the throat plate
3. Press the switch to start the machine (the bag is carried through the sewing gap by the feed mechanism)
4. Support the bag as it feeds through the machine to achieve a straight seam
5. When the bag is sewn, let the machine run on to create a short 'chain' of thread and gently turn the machine to the left to allow the knives to cut the thread

Keep hands and fingers away from the moving parts (the needle, feed dog and presser foot).

Maintenance:

Always disconnect the machine before cleaning or maintenance

Fitting a new needle:

1. Unplug the machine and place it with the handle flat on the table so that you are looking at the looper cavity and the needle guard
2. Remove the pulley guard
3. Raise the presser foot and rotate the machine manually until the needle is at its highest position.

4. The needle is held in the needle bar by a nut. Loosen the nut with a 3/8 open ended wrench (provided). Do not use pliers.
5. Place the new needle in the needle bar, making sure that it is fully inserted and that the long groove faces you, with the needle scarf to the back. The grove lips should match the base of the machine and the eye should face you.
6. Tighten the nut to clamp the needle in place. Do not use excessive force.
7. Lower the presser foot and check to see that the needle is passing through the middle of the needle guard
8. Replace the pulley guard and re-thread the machine.

Threading the needle:

1. Pass the thread through 1st and 2nd eyelets and around the tensioning stud between the two tensioning discs.
2. Pass it through the 3rd eyelet close to the needle guard
3. Pass it through the slotted opening in the needle guard, through the needle and then through the opposite side of the needle guide
4. Push the thread through the eyelet to reach the front of the needle
5. Push the thread through the needle eye from the front and pull about 8 cm of thread through
6. Test the machine on an empty bag.

Fitting a new cone of thread:

1. Unscrew the wing nut at the base of the thread stand
2. Remove the thread clamping bolt
3. Take a new cone, place it on the clamping bolt and put it on the thread stand
4. Re-attach the wing nut and tighten it. The cone should not rotate or wobble on the stand.

Thread tension adjustment:

The outer nut on the tensioning discs is a locking nut and the inner one is to adjust the tension. Turning the tensioning nut clockwise increases the tension and turning it anticlockwise reduces the tension on the thread. Start with minimum tension and examine the stitch. If it is too loose, gradually tighten the tension nut until a proper stitch is obtained. Lock the nut in position.

Replacing the drive belt:

1. Unplug the machine and remove the thread cone holder
2. Remove the handle by unscrewing 2 screws
3. Loosen the 2 screws on the motor mounting
4. Press the motor mount closed to give slack to remove the old belt and fit a new one around both pulleys
5. Apply tension to the belt by opening the motor hinged mounting bracket and tightening the two screws. The belt should have 3-4mm play at the centre.
6. Re-attach the handle and cone thread holder.

Daily maintenance:

1. Press the oil pump button 2-3 times while the machine is running until you see oil flowing through the feeder tube. This should be done every 2 hours of machine use.
2. Check the level of the oil pump, always replacing the cap to prevent oil lines becoming contaminated with dust and getting blocked
3. Remove any dust with a brush – especially around the bottom of the machine, the looper and the knives

If the wick that carries the oil becomes worn or thin, replace it immediately to avoid damage to the machine

If cleaning is done daily it will increase the life of the machine.

Weekly maintenance:

1. Check the motor brushes to ensure that they are more than 6mm long. Replace if they are shorter than this, by lifting out the brush holders and fitting new brushes
2. Clean the machine in an oil bath by filling a small tank to 6cm deep with cleaning oil
3. Remove the looper cover at the bottom of the machine and the belt/pulley cover and handle
4. Plunge the machine vertically into the oil bath so that it is immersed to the level of the throat plate
5. Turn the machine manually at the pulley so that moving parts are cleaned by the oil
6. Remove and allow excess oil to drain back into the tank
7. If necessary, loosen stubborn dirt with a brush and re-immerse the machine.
8. Clean the outside with a small oiled brush, wipe clean with a soft absorbent cloth

Never use solvents to clean the machine.

Seed cleaners/Winnowers

At its simplest, a seed cleaner is a mesh table on which grain can be spread out and examined. Dust and small stones fall through the holes in the table and larger leaves, stalks, mouldy grains etc can be picked out. Mechanised cleaners consist of an inclined vibrating flat screen (Fig 4.12). Grain is fed onto the screen and the vibration assists in separating the contaminants. These machines cause considerable dust and should be located in an area where dust can be prevented from contaminating other equipment or products. They should be cleaned daily by brushing out dust and contaminants.

Fig 4.11 Seed cleaner

When it is necessary to wash grain to remove dust and other contaminants, this is done using a trough or tank containing clean water and fitted with a drain tap so that water can be regularly replaced. Iron fragments are removed from the grain using permanent magnets, (electromagnets are not recommended because of the risk of power failures, which would cause the magnet to drop the collected iron filings into the grain). Other types of metal particles must be removed by hand on the inspection table.

Checklist 4 a
Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.

Question	Tick	Notes
1. Do you know where to obtain the following equipment?		
Bagging equipment		
Conditioners		
Cyclone separators		
Diesel engines		
Dryers		
Maize dehullers		
Maize shellers		
Mills		
Rice dehullers		
Seed cleaners/ Winnowers		
2. Do you know where to get spare parts for the above equipment?		

Food quality and food safety

The terms food quality and food safety can sometimes be confusing. Food quality refers to the factors that influence how a consumer chooses a particular product. They may be positive factors, such as the golden brown colour of a loaf or the fineness of flour, or they may be negative factors, such as contamination of flour with insects, mould growth, off-odours or a burned bakery product. Food safety refers to anything that could harm a consumer. This could include

- Microbiological: moulds, bacteria and viruses
- Biological bone, hair, insects and faeces
- Chemical pesticides, toxins, cleaning liquids and disinfectants
- Physical wood, string, dirt and stones

Successful millers already use quality assurance to consistently product safe, high quality products and thus increase their reputation and numbers of customers. This is going to be a legal requirement, when the new “National Food Safety Bill” is passed by the Parliament of Uganda All processors (and their supplies and retail/wholesale customers) will be required to have formal quality assurance procedures based on Good Hygienic Practices (GHP), Good Manufacturing Practices (GMP) and HACCP.

Various aspects of a quality assurance management programme are outlined below. They are the first steps in the development of written GHP and GMP programmes and will enable the entrepreneur to identify potential hazards and critical control points in the milling and baking processes.

The main quality characteristics of flour are that:

- It should be pure flour without any contaminants
- It should be fine flour
- It should have the correct weight in a pack.

One of the most important aspects of QA is preventing food hazard contamination. The main contaminants that are found in grain are:

- Foreign materials (soil, weed seeds, stones, string, leaves etc.)
- Infestation by insects, excreta, hair from rodents or feathers from birds
- Mould growth
- Chemical residues (pesticide, oils or grease from vehicles or machinery and cleaning liquid residue)

A well-designed QA programme prevents these contaminants from entering the mill, or discovers and removes them before they can contaminate the flour. Millers should also check for physical damage to grains and for immature grains which can impair product quality or lead to microbiological contamination.

The other components of a QA programme, in addition to checking incoming grains, are to check:

1. The correct operation of seed cleaners, dehullers and mills
2. The building
3. Implementation of cleaning programmes
4. Flour quality and fill weights
5. Correct sealing of bags/sacks

Each of these is summarised in Table 4.10.

Table 4.10 QA control points for flour milling

Processing stage	Activity by miller	Critical Control Points
Grain production	Advice to farmers during cultivation in contract farming[2]	Types, amounts and timing in the use of agricultural chemicals
Harvest and on-farm storage	Advice to farmers on timing of harvest and post-harvest storage conditions in contract farming	Maturity at harvest, drying to correct moisture content, cleaning and the avoidance of contaminants, type and condition of storage structures, prevention of insect/rodent attack
Raw material transport	Transport in sacks to mill	Cleanliness and condition of sacks, cleaning lorry or vehicle before and after transport of raw materials
Reception and storage at the mill	Weighing incoming grain, inspection and quality checks, supervision of grain storage	Presence and weight or volume of contaminants, grain moisture content, condition of storeroom, prevention of insect/rodent attack, routine cleaning schedules.
Seed cleaning	Operation of seed cleaner(s)	Efficiency of cleaning, minimising contamination by dust
Dehulling	Operation of dehullers(s)	Dehuller settings for efficient hulling, minimising contamination by dust
Milling	Operation of mill	Machine settings for optimum milling efficiency, quality of flour, minimising contamination by dust, routing cleaning schedules and verification.
Flour storage	Supervision of flour storage	Condition of storeroom, prevention of insect/rodent attack, routine cleaning schedules and verification, (develop an inventory and rotation control system).
Packing	Packing flour into bags or sacks	Correct fill weights, adequate sealing of bags/sacks,
Distribution	Dispatch products in required amounts to retailers or customers	Cleaning programme for dispatch lorry or vehicle, implement a delivery inspection and inventory system to ensure customers receive the products and quantity ordered

Quality of raw materials

Poor quality grain is one of the most common problems facing millers and is caused by inadequate post-harvest control by farmers and inadequate storage conditions in the mill. Most millers buy their grain from farmers and have little control over the way in which grain is grown, harvested, stored or transported. Contract agreements with farmers can improve the amount of control that millers have over the quality of raw materials.

Contracts with farmers

Quality assurance in contract growing covers the following areas:

- Correct application of chemicals during cultivation
- Harvest at the correct stage of maturity
- Correct threshing and winnowing
- Adequate drying and post-harvest storage
- Correct packaging and transport of grains.

Contamination by pesticides and chemical fertilisers can be due to inadequate information or training for farmers in the amounts of chemicals to use, or the timing of their application. As part of contract agreements, millers can prevent such problems by supervising chemical use and checking that chemical applications are in line with manufacturers' recommendations. The use of agricultural chemicals is controlled by law in Uganda and millers should check with the Ministry of Agriculture, Animal Industries and Forestry and the UNBS for details of the specific laws.

Millers can also specify or supervise harvesting to ensure that this is done at the correct stage of maturity and minimise contamination. Correct post-harvest storage is needed to minimise the risk of mould growth on grains. Moulds give an unpleasant smell to flour that makes it unacceptable to consumers and may also damage their health. Some species of moulds produce poisons in cereals, known as 'aflatoxins'. These have no taste and may be eaten by consumers, with the risk of long-term damage to the liver, digestive system and kidneys. The correct storage conditions for grain are summarised in Table 4.11.

Table 4.11 Summary of guidelines for correct grain storage

1. Make sure the storeroom is waterproof by locating it on well drained land, raising it above the ground and fitting a waterproof roof
2. Prevent the temperature in the store from fluctuating by using insulating materials (brick, mud, clay, wood or other insulation), painting the outside white and fitting an overhanging roof to keep sunlight off the walls.
3. Ensure that the store is insect-proof, rat-proof and bird-proof
4. Thoroughly clean storerooms by removing and burning all old grain, straw, insects etc. to prevent contamination of new grain
5. Make sure that grain is properly dried before putting it into a store
6. If chemical insecticides or fungicides are used, ensure that manufacturer's recommended dosages are followed.
7. Regularly check the grain for infestation, signs of mould or discolouration and ensure that it is not getting hot (each is a sign of excessive moisture). If these are found, remove the grain and re-dry it.

Most grain is transported in sacks, but the quality of re-used sacks is often not checked. Dirty sacks contaminate grain and inadequately sealed sacks allow birds, insects and rodents to contaminate the grain. Control over transport to the mill is part of a QA scheme and millers should supply good quality sacks for collecting grain and preferably arrange transport to collect grain directly from the farmers using their own vehicles, or contracted haulers' vehicles that have been inspected to ensure that they are clean.

When sacks arrive at the mill, they should be checked to ensure that there are no holes in the sacks or loose sewing at the top. Sacks should be dry and clean and not obviously contaminated by oil, grease, kerosene etc. Grain may contain field contaminants (weed seeds, stalks, soil, stones and dead or living insects), as well as metal or wood fragments, diesel, oil, etc. from transportation. When the sacks are opened at the mill, the grain should be spread onto an inspection table checked visually for:

- Contamination by foreign materials
- Damage or contamination caused by insects, birds and rodents
- Excessive moisture content or mould growth
- Broken or immature grains

Foreign materials, mouldy or discoloured grains should be removed by hand. Some millers also wash grain in a tank to remove sand, small stones or dust. A periodic QA check is to collect and weigh the contaminants that are separated from grain. The weight can be expressed as a percentage of the batch weight using the calculation:

$$\% \text{ contamination} = \frac{\text{weight of contaminants}}{\text{weight of batch}} \times 100$$

A record of the weight and types of contaminants from different farmers over a period of time to negotiate and either reduce the price or improve the quality of future deliveries. If farmers know that such checks are being made, it may influence them to improve their handling and storage procedures, particularly if the miller is willing to offer a price premium for higher quality grain. Millers should keep a small sample of grain from different suppliers so that if there is any dispute over quality, the sample can be used for further testing. One component of the HACCP system is that processors should be able to trace their ingredients back to individual suppliers. This applies today for those who are exporting and will in the future to all processors. Keeping samples and written records of purchases and sales is part of a HACCP system.

This inspection and removal of contaminants is essential to ensure that high quality flour is produced and to protect the mill from damage and hence additional operating costs for repairs,

Moisture content

The correct moisture contents for safe storage of grains and flours are shown in Table 4.12.

Table 4.12.a Moisture contents of cereals for safe storage and milling

Cereal	Moisture content (%) Storage Uganda	Codex Standards (maximums)	Milling Moisture
Maize (shelled)	13.5	15.5	15.0
Millet	16.0	13.0	13.0
Rice	15.0	15.0	14.0
Sorghum	13.5	14.5	11.0-13.0
Wheat	13.5	15.5	14-16

(Sources: Codex Standards are from officially published standards. All other figures: Fellows, P., Midway Technology Ltd. Bonsall, U.K.))

Table 4.12.b. Moisture content (%) for the safe storage of flours

Flour	Moisture content (%) Storage Uganda	Codex Standards (Maximums)
Maize flour	13.5	15.0
Millet flour	15.5	13.0
Rice flour	13.0	
Sorghum flour	14.0	15.0
Soy protein flour	9.0	10.0
Wheat flour	12.0	15.5

(Sources: Codex: Standards are from officially published standards. All other figures: Fellows, P., Midway Technology Ltd, Bonsall, U.K.)

With experience, a miller can assess the correct moisture content of grains by placing them on a hard surface and tapping them with a metal or stone weight. The hardness (or softness) of the grain indicates the approximate moisture content. A more accurate method is to dry a weighed sample of grain in a laboratory oven at 100°C for 4 hours (or 104°C for 2 hours), cool and re-weigh it. The weight loss is calculated as moisture content using the following formula:

$$\% \text{ moisture content} = \frac{\text{Initial weight of grain} - \text{Final weight of grain}}{\text{Initial weight of grain}} \times 100$$

Quality checks on flours

If adequate quality assurance procedures are followed for inspection of grains, operation of the milling equipment and storage of flour, there are relatively few checks that are needed on the flour. The main one is to ensure that the weight filled into bags or sacks is not below the weight declared on the label or printed on the sack.

Building inspection and routine cleaning programmes

Flour dust accumulations attract insects and rodents, which in turn contaminate the products. It is therefore essential that a monthly inspection be made of floors and walls for cracks and to ensure that windows and ceiling panels are intact and in place. This should be part of the job description for a member of staff, who should tick off each check against a written checklist. The mill owner or manager should ensure that the checks are properly done. All spilled grain and flour should be cleaned up at the end of each day's production to prevent flour mites and other insects from breeding and contaminating the products. If infestation is found it should be treated by spot-spraying, but this indicates a failure in a cleaning programme and changes should be introduced to improve cleaning. Brightly coloured brooms, brushes and cloths should bee used so that any bristles or cloth fragments to be easily seen if they contaminate the flour. Fumigants can be used to disinfest grain stores and the following are approved in Uganda: lindane, bromophos, malathion, dichlorvos, piperonyl butoxide, pyrethrum or combinations of these. Manufacturer's instructions must be strictly observed and made available to operators in their language. Methyl bromide gas is now being phased out under the Montreal Protocol because it destroys the ozone layer.

Process control

Seed cleaners, dehullers and mills should be checked daily for loose nuts or bolts and to ensure that settings are correct. Parts that are likely to wear out should be checked monthly as part of a planned maintenance programme. Contaminants such as metal fragments, pieces of hardened flour, wire or nylon from sieves or cotton fibres from sacks can each contaminate flour during milling. Sieves should be used at points throughout the process to collect larger contaminants and checked regularly. Contaminants should be recorded and any sudden increase, which indicates that a problem has arisen, should be investigated and corrective action taken. Magnets remove any ferrous (iron and steel) metal fragments from grain or flour. Permanent magnets are preferred because electromagnets can drop an accumulated mass of filings into the flour if the power fails. Magnets cannot pick up non-ferrous metals and these must be checked for by visual inspection.

Packaging and fill weights

The weight of flour in a sack or bag is controlled by law in Uganda and should be routinely checked to ensure that operators are filling them to the correct weight. In larger mills, investment may be justified in a bagging machine that fills bags to the required fill-weight. Stored flour should be sold using the FIFO ('first in first out') system.

Checklist 4 b **Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer**		
Question	**Tick**	**Notes**
1. Do you have schedules for routine inspection and cleaning of the processing unit?		
2. Does your processing room meet legal requirements for hygiene and sanitation?		
3. Do you know how to test your products?		
4. Do you know how to check your packaging?		
5. Do your products meet legal requirements for product specification?		
6. Do your products meet legal requirements for fill-weight and label design/ information?		

5 Bakery Products and Production Methods

All bakery products are made from basic ingredients, which have the following functions:

Flour	Contains gluten, which contributes to the crumb structure and retains gas in raised bakery products. Starch in flour forms a paste that is set by heat during baking. Changes to starch contribute to staling of bakery products.
Yeast	Produces gas (carbon dioxide) to raise dough, contributes to dough conditioning and flavour.
Salt	Helps control yeast fermentation, toughens dough by strengthening gluten, extends dough development and mixing time.
Sugar	Fermented by yeast, sweetens dough, contributes to development of golden brown colour of bakery products, tenderises crumb and extends shelf life.
Shortening	Assists gas expansion during fermentation, tenderises crust, extends shelf life.
Milk	Improves the flavour and texture of products
Egg	Gives strength and flavour to products
Baking powder	Produces carbon dioxide to raise dough
Pre-mixes	Reduce dough preparation time; ensure even mixing of minor ingredients and help to avoid operator errors.

These are supplemented with a wide range of other ingredients that give special flavours, colours or textures to products.

Bread, buns, pizza bases and doughnuts are produced from hard wheat flour[2] and fermented using yeast. Biscuits, pastries, scones, cakes and flan/pie casings are made from soft wheat flour using baking powder as a raising agent and flat breads are made from the same flour without a raising agent. Each of these products can be made using different ingredients, fillings, shapes, colours, flavours and sizes. It is not possible in a manual of this type to describe each of these in detail and bakers should consult recipe books and/or texts given in Annex A for details of product variations.

Ingredients

Flours

There are different grades of wheat flour, each described by their 'extraction rate' (the amount of starchy material extracted from the grain). Common white flours include 'straight run' flour which contains 76-78% of the original wheat and 'patent' flour. Cakes and sponges are made using patent flour to give a brighter, glossier crumb than those made using straight-run flour. Wholemeal and whole-wheat flours are used less frequently in Uganda, but the demand for these types of bread is increasing. They have at least 95% extraction and often 100% extraction (i.e. the whole of the grain including bran and germ is ground to a meal).

Self-raising flour contains approximately 20g baking powder per kg of flour. However, it is not recommended for commercial bakers because over long storage periods the baking powder loses its activity. It is better for a baker to blend in the required amount of baking

[2] Wheat flours contain a protein (gluten) that creates the characteristic texture of bakery products. They are either 'strong' flours with a higher gluten content (made from 'hard' wheat) or 'weak' flours with less gluten (made from 'soft' wheat).

powder to plain flour, as it is needed. Corn flour forms a thick cloudy gel when boiled with water and is used to thicken sauces, glazes and custards. Arrowroot flour is similar to corn flour, but forms a clear gel and is therefore preferred for glazes. Cassava, sorghum, rice or maize flours can be used as a partial substitute for wheat flour, but they do not contain gluten and therefore cannot be used above 25-30% of the weight of wheat flour in bread-making. They can be used in cakes, tortillas and biscuits. Soya flour, in the form of defatted soy flour (DSF) is finding new uses in traditional flat breads and buns because small inclusion rates have been shown to improve product quality, accelerate production, reduce costs and reduce wastage. Other flours such as millet, bean and pea flours can also be used in composite flours for biscuits, cakes etc.

Water

During dough preparation, wheat proteins absorb water and form gluten. The amount of added water depends on the water absorbing capacity of the flour (Section 5.4.1). If the water content is too low, a 'tight' dough is produced and the product will have a smaller volume and a heavy texture. 'Hard' water may also create a tight dough and bakers need to know the type of water in their area so that they can adjust recipes and process conditions. Water can be tested for hardness at UIRI, UNBS or one of the commercial analytical companies in Kampala. It goes without saying that the water must be safe and clear of contaminants or micro-organisms.

Yeast

'Bakers' yeast' ferments sugars in the dough to produce carbon dioxide gas and alcohol. It is the gas that is important and the alcohol is driven off during baking. Bakers use either pressed fresh yeast or dried yeast. Pressed yeast should be stored in a refrigerator and is active for a few weeks, whereas dried yeast can be stored for years, losing 2-3% of its activity per year under proper storage conditions. A test for yeast activity is described later in this manual.

The amount of yeast in dough is normally 0.3-1.0% of the weight of flour. Pressed yeast is mixed with water and added directly into the dough. Dried yeast is activated by mixing it with five times its weight of warm water, a little sugar and leaving it stand until it becomes cloudy with visible gas bubbles. The amount of yeast depends on the temperature and/or the time of fermentation. A change in fermentation temperature of 1.1°C requires a change in the amount of yeast of 20% (e.g. an increase in temperature from 25°C to just over 26°C reduces the amount of yeast by 20%).

Worked example 10: Factor to calculate the weight of yeast required for different fermentation times

For 100kg flour, assuming 1% yeast and a 3-hour fermentation:
Therefore the fermentation will require 1% of 100kg = 1 kg yeast
And the factor then becomes 1 x 3 = 3

So a 2-hour fermentation of 100kg flour will require 3 divided by 2 = 1.5 kg yeast.

When smaller amounts of flour are prepared, the factor is increased from 3 to 4.2 because the dough pieces cool more rapidly, thus slowing the fermentation. So for 100kg flour fermented over 3 hours at 26°C the amount of yeast would then become 4.2 divided by 3 = 1.4 kg (or 14g yeast per kg of flour) and for a 2 hour fermentation it would be 4.2 divided by

2 = 2.1kg (or 21g yeast per kg of flour). When there is a delay between removing the dough and baking (for example during hand-moulding), the factor should be reduced by around 10% to take account of the additional time for yeast activity.

Salt

Salt gives flavour to bread, strengthens the gluten, controls the yeast fermentation and helps retain moisture to reduce staling. It easily absorbs moisture from the air and should be stored in a dry place off the floor. Salt must not come into contact with yeast because it kills it. It should be dissolved in water before adding it to the flour, or sieved into the flour before mixing. In Uganda, sweeter, less salty breads are preferred, containing less salt (14-17g per kg flour) compared to European breads (up to 25g per kg flour).

Sugar

Flour contains 2-3% natural sugar and a further 2% sugar is often added in Uganda to make sweeter bread. White granulated sugar is preferred for most bakery products, but in Uganda pure sugar is difficult to obtain due to traces of molasses that give a pale brown colour. Brown sugars are used in some rich fruit cakes where they contribute to the flavour as well as the colour of the product. Other types of sugars, including icing sugar, Demerara sugar, golden syrup, treacle and honey each have specialist uses, particularly in patisserie products. Confectioners' glucose (or 'glucose syrup') is a thick syrup made from a mixture of sugars and dextrins. Some bakers use high 'Dextrose Equivalent' (DE) syrups in cakes to keep them moist during storage.

Fat

Special bakers' fats (or 'shortenings') are used for pastry products. In cake making, high quality margarine that has good creaming properties is needed to retain the air that is beaten into the batter (Section 4.2.4). Shortenings may be mixed with margarine or butter to improve the shortness of the cake crumb. Butter has poorer creaming properties than shortenings but gives a better flavour. It is normally mixed with an equal weight of shortening. However, shortenings are 100% fat and butter is only 84% fat, so only 7/8th of the weight of butter is used when substituting with shortening. Specially formulated margarines, including cake margarine, pastry margarine (for puff pastry) and salt-less margarine for creams may be bought on special order. In cake making, a good quality margarine that has good creaming properties is necessary to hold the air that is beaten into the batter. Lard is used for savoury pastries because it gives a shortness that cannot be matched by other fats. It cannot be used in cakes because it has poor creaming properties. Fat is not needed for bread production, but adding 0.5-1% of the weight of flour improves the quality of bread. It gives increased loaf volume, a more tender and thinner crust, a better crust colour, a softer crumb and an improved flavour.

Eggs

Eggs should be fresh and without visible damage. Because eggs vary in weight, it is better for a baker to use a recipe that has the weight of the egg contents rather than the number of eggs. The weight of yolk is approximately half that of the white and a medium sized egg (e.g. 53g) would therefore have approximately 15g of yolk and 30g of white after the shell is removed. Egg yolks or whites should be covered with a boiled damp cloth to stop a skin forming on the surface and kept in a refrigerator to slow the growth of bacteria. Dried egg powder is only used for cheap, lower quality cakes. It is reconstituted using 1 part egg powder to 3 parts water and should be used immediately to avoid the risk of food poisoning.

Baking powder, pre-mixes and flavourings and colourings

Baking powder can be bought from grocery shops, but it may have lost some activity if it has been stored for too long. A baker should therefore make baking powder as needed, using acidic cream of tartar (acid calcium tartrate) and alkaline bicarbonate of soda (sodium bicarbonate) in the ratio of two parts to one. When water is added in the batter, the two components react to produce carbon dioxide. The two components should be sieved together six times and the mixture should then be sieved with flour at least three times to ensure an even distribution of baking powder.

Pre-mixed dough improvers are becoming more readily available to bakers in Uganda via import agents. Bakers can make their own pre-mixed ingredients (e.g. by rubbing all dry ingredients in a recipe into the fat in bulk). This saves time during production and reduces the risk of any ingredient being forgotten in a batch of dough.

Flavourings are extracts, essential oils and essences. Extracts (e.g. vanilla) come from natural materials and are dissolved in alcohol. They give the most natural flavours and are often the most expensive. Essential oils (e.g. lemon oil, orange oil, lemon grass oil, citronella oil and peppermint oil) can withstand the high temperatures of baking to give flavour to cakes or biscuits. Essences are artificial flavourings that resemble natural extracts (such as pineapple, lemon, orange, chocolate or vanilla). They are cheaper than extracts but do not withstand baking temperatures and are therefore only used in creams and icings. For expensive products, different types of alcoholic spirits and liqueurs, including rum and brandy may also be used to flavour cakes after baking. Spices can be used as spice oils (e.g. anise, cloves, coriander, cassia, cinnamon, caraway, ginger, mace and nutmeg) or ground powders. Colourings can also be obtained as either liquids or powders. Both types have intense colour and should be carefully diluted before use to prevent streaks of colour in the product.

Nutrient Fortification

Uganda recently became the first country in East Africa to launch a national programme to enrich processed foods with vital nutrients, which can boost health. UNBS has already drafted a “Food Fortification Regulations and Standards” policy that the cabinet will consider. Bakers should seek information on this programme from UNBS. Soya and other flours, for example, can increase the protein content and nutrient values of products for young children and pregnant and lactating mothers.

Fortified foods will be identified by the Fortification Label, which means that the Government of Uganda has endorsed that the product is fortified according to the required standards.

Processing conditions

Ingredients should be accurately weighed in each batch and the same weight of dough or batter should be used for each piece of baked product. Accurate scales should be used and in larger bakeries a dough divider may be needed to handle the larger amounts of dough. Dough loses 10 - 12.5% of its weight during baking and the following formula can be used to calculate baking losses:

$$\% \text{ loss} = \frac{(\text{weight of dough before baking}) - (\text{weight of product after baking})}{\text{weight of dough before baking}} \times 100$$

The required weight of dough pieces is calculated using the following formula:

Required weight of final loaf = A (g)
Baking loss = B (%)
Weight of dough piece = A + (A x B) (g)

Worked Example 11: Calculation of dough weight

If the baking loss = 10%, for a 400g loaf:
the weight of dough required = 400 + (400 x 10%)
= 400 + 40 = 440g

Other processing conditions such as fermentation times, mixing times etc. should be accurately controlled and measured with a clock or watch. The temperature of the dough controls the speed of yeast fermentation and so partly determines the amount of product that can be produced per day. It should be between 25-29°C to allow the yeast to work fastest. If it is too high (above 49°C) it will kill the yeast and if it is too low the yeast will not ferment the dough quickly enough.

One of the easiest ways of adjusting the dough temperature is to control the temperature of added water and there are two methods that can be used:

1 Simple method: Measure the temperature of the flour. Double the required dough temperature and subtract the flour temperature.

Water temperature = (Dough temperature x 2) – flour temperature

Worked Example 12: Calculation of dough temperature

If the required dough temperature is 28^{o}C and the flour is at 25^{o}C:

Water temperature = (Dough temperature x 2) – flour temperature
= (28 x 2) – 25
= 56 – 25
= 31^{o}C

This method works well for large batches of dough that can retain heat, but water should be a few degrees hotter for small batches or if the weather is cold.

2 Major factor method: This method also takes the temperature in the bakery into account. Select a day when particularly good bread is produced and note the temperature inside the bakery and the temperature of the flour and water. Add these temperatures together to get the Major Factor Figure. This number can then be used in all subsequent production to make consistent products when the temperatures change.

Worked Example 13: Dough temperature using the Major Factor method

Bakery room temperature = 25^{o}C
Flour temperature = 23^{o}C
Water temperature = 32^{o}C
Total (Major Factor Figure) = 80

If on a following day, the room temperature rises to 27^{o}C and the flour temperature to 25^{o}C, these temperatures are subtracted from the Major Factor figure to calculate the required water temperature:
Major Factor figure = 80
Less flour temperature 25
Less bakery temperature 27
Equals water temperature (80 - 25 - 27) = 28^{o}C

Cooler water is used to compensate for the increase in room and flour temperature. Note: if the calculated water temperature is above 34°C, the yeast should be mixed with a little cool water first before adding to the dough to prevent the yeast being damaged.

The temperature of baking must be carefully controlled to ensure consistently high quality products. Recommended baking temperatures for different categories of product are shown in Table 5.1.

Table 5.1. Baking temperatures and times for different products

Product	Baking temperature (°C)	Baking time (min)
White bread, Bread rolls French and Vienna breads	249	40-45 10-12 20-25
Puff pastry (egg-washed and unfilled)	238-249	5-10
Plain fermented buns	238	8-10
Choux pastry (éclairs, cream buns)	232-238	20-25
Buns (medium rich, e.g. Chelsea buns)	232	12-15
Scones	232	15-18
Finger sponges	232	6-8
Plain biscuits	232	10-15
Swiss rolls	232	5-6
Small cakes	221-232	10-12
Madeira, fairy cakes	221	10-12
Shortbread (small)	221	10-12
Rich buns, Puff pastry (sugar glazed or filled), Sausage rolls, Sponge cakes	215-227	12-15
Meat pies, patties (small)	215	15-20
Short crust pastry (e.g. pastries, tarts, custard pies) Sandwich sponge cakes, Rich biscuits	204-215	15-18 18-20
Madeira cake, light gateaux	204	
Shortbread (large) Rich sweet pastry	193-204	15-18
Malt and fruit breads	163-204	10-15
Fruit cake	177-188	60-70
Macaroons	171-182	10-12
Birthday cakes	166	
Rich cakes Gingerbread	160	2-3 hours 15-20
Meringues	121	10-15

(Ref: Opportunities in Milling and Baking, Fellows and Axtell, 2003 – see Annex A)

Fermented products

Bread

The traditional ‘straight dough’ or 'bulk fermentation' method of white bread production has eight main stages described in Table 5.2. Even a small change in the recipe or process conditions can produce a completely different product, so it is essential to make sure that exactly the same method is used for each batch of product.

Pizza dough is made in a similar way to bread dough, proved for 5-15 minutes at 35-40^{o}C, divided into balls (e.g. 175 g +/- 5g), rolled to a flat disc (e.g. 1 cm thick, 15 cm diameter) and proved for 10-15 minutes. Different toppings (e.g. cheese, onion, tomato paste, tomato, fish, chilli/red pepper) are added and it is baked at 230^{o}C for 10-15 minutes.

Double-layered pitta breads are made in a similar way to bread, but they are given a second proofing of 5-10 minutes before baking. This allows the dough to relax, aerate and develop a thin skin. When they are baked in a very hot oven (350^{o}C) for 18-100 seconds, the skin forms a crust and the steam inside the dough together with carbon dioxide from the proofing, force the top and bottom crusts apart and creates two layers.

Doughnuts

A thin batter is first made with water and yeast, 10% of the sugar and a portion of the flour. It is fermented for 30 minutes and the remaining ingredients are added to form the dough. This is again fermented for 30 minutes and formed into 60g balls or rings. Ring doughnuts are made by removing the centre from the dough piece with a ring cutter after it has been proved and knocked back. The dough is allowed to rest for 10 minutes and then moulded into the final shape and proved at 35^{o}C and 85% relative humidity. Pieces are fried at 185-193^{o}C in a deep fat fryer, ensuring that both sides are golden brown. The doughnuts can be coated with sugar while still hot, or jam can be injected into the centre using a piping bag, or filled with jam and/or cream by cutting a slit in the side.

Table 5.2 Process for bread

Stage In Process	Notes
Mix	Accurately weigh all dry ingredients into a mixing bowl. Dissolve the yeast in warm water (30-34°C). Dried yeast is used at 50% of the weight of fresh yeast. Add the yeast to other ingredients and start the mixer. Use a standard mixing time, dough temperature and mixer speed. Check the dough at intervals and continue mixing until it is soft and smooth, but not sticky.
Knead	To develop the gluten structure and produce a smooth silky finish. Machine-mixed doughs require only a short gentle kneading after mixing
Proof (ferment)	E.g. for 3 hours at 27°C in a proving cabinet. Ensure that a skin does not form on the dough by spraying it with water or covering with a clean damp cloth. Allow the dough is to rise until it has approximately doubled in size. If it is proved for too long it will smell of alcohol; if it is not proved for long enough it will not have risen sufficiently.
Knock back	To expel the gas and reduce the size of gas bubbles. Initially, dough is tough, but after about ¾ of the fermentation time it is full of gas and the gluten relaxes. The inflated dough is knocked back to its original size by kneading. This improves the quality of a loaf because it stretches and conditions the gluten, removes large gas holes, gives a better shape and volume and produces a more stable crumb structure.
Proof	To allow the dough to relax
Divide and mould	To form the correct sized pieces of dough. Cut the dough into uniform sized pieces and weigh to ensure that each is the same weight (see also legal requirements). At a larger scale, mechanical dough dividers can be used. The dough pieces are allowed to rest for a short time.
Final mould	The dough is moulded into the required shape by hand or using a mechanical moulder. Dough is placed on a lightly floured table and flattened with a clenched fist. The two opposite edges are then folded to the centre and then rolled into a cylinder (or ropes that are then plaited, or rolled out flat for pizza bases). Crusty breads are baked on trays rather than in baking tins. Because this dough has to support its own weight and retain its shape during baking, the dough should be firmer than for tin breads.
Final proof	To allow the yeast to gently inflate the dough. The dough pieces are placed into greased tins or trays to allow uniform expansion. An experienced baker judges the proving time by looking at the volume of the dough and whether the surface springs back when lightly pressed. If a finger impression remains in the dough, it is a sign that it is over-ripe or over-proved. The dough should have a smooth, silky appearance. Some doughs are glazed with egg wash before both first and second provings to give a golden brown crust colour
Bake	Bake at the required temperature and for a pre-set time. Check if a loaf is adequately baked by lightly tapping the side or base. A properly baked loaf has a hollow sound. When baking loaves or rolls on baking trays, ensure sufficient space between the dough pieces to allow for expansion and to bake the sides. Ensure that all spaces between pieces are the same to achieve uniform baking.
Cool	To room temperature on cooling racks.
Pack/ Label	(optional) Pack in paper bags, or in polythene bags that are sealed using a tape sealer or an electric heat sealer. Make sure that the loaves are properly cooled before packing to prevent moisture condensing on the inside of the pack and causing mould growth. Check that label is correct for type of product. Check fill-weight and seal.
Store	Store in a cool dry place away from sunlight.

Buns

Buns may have added fruit (any dried fruit including sultanas, currants, cherries or mixed fruit peel), spices, essences, egg, milk powder or butter. Fruit is added after mixing to avoid crushing it and spoiling the appearance of the product.

Table 5.3. Process for buns

Stage In Process	Notes
Prepare the 'ferment'	Mix yeast, flour and sugar (e.g. 0.05 kg yeast, 0.1 kg flour, 0.012 kg sugar with 0.5 kg water 0.025 kg milk) to a thin batter. There is vigorous gas production to form a frothy mass (the 'ferment').
Mix	Add the ferment to the dough ingredients (e.g. 0.9 kg flour, 0.124 kg fat, 0.1 kg sugar, 0.1 kg egg, salt and flavourings as required) and mixed to form the final dough. Check the dough at intervals and continue mixing until it is soft and smooth, but not sticky.
Knead	To develop the gluten structure and produce a smooth silky finish. Machine-mixed doughs require only a short gentle kneading after mixing
Proof (ferment)	For 30 minutes at 27°C in a proving cabinet. Ensure that a skin does not form on the dough by spraying it with water or covering with a clean damp cloth. Allow the dough is to rise until it has approximately doubled in size. If it is proved for too long it will smell of alcohol; if it is not proved for long enough it will not have risen sufficiently.
Knock back	To expel the gas and reduce the size of gas bubbles. Initially, dough is tough, but after about ¾ of the fermentation time, it is full of gas and the gluten relaxes. The inflated dough is knocked back to its original size by kneading. Knocking back stretches and conditions the gluten, removes large gas holes, gives a better shape and volume and produces a more stable crumb structure.
Divide	Cut the dough into uniform sized pieces and weigh to ensure that each is the same weight. At a larger scale, mechanical dough dividers can be used. The dough pieces are allowed to rest for a short time.
Mould	The dough is moulded into the required shape by hand or using a mechanical moulder.
Final proof	To allow the yeast to gently inflate the dough. The dough should have a smooth, silky appearance.
Bake	Ensure sufficient space between the dough pieces to allow for expansion and to bake the sides. Ensure that all spaces between pieces are the same to achieve uniform baking. Some buns are glazed with a sugar wash (2 parts egg, 1 part sugar and 1 part water, whisked together with a flavouring or essence (e.g. lemon, vanilla etc) after baking while the products are still hot, to give a shiny surface to the product.
Cool	To room temperature on cooling racks
Pack/ Label	(optional) in polythene bags, using a tape sealer or an electric heat sealer. Check that label is correct for type of product. Check fill-weight and seal.
Store	Store in a cool dry place away from sunlight.

Chemically raised products

Products such as cakes, scones or soda bread are known as chemically-raised doughs because they rely on gas produced from baking powder to raise the dough and produce the crumb texture.

Biscuits and cookies

Biscuit or cookie dough is made by either 1) adding ingredients in turn to the flour with constant mixing, or 2) by mixing together all the ingredients except flour and then carefully mixing in the flour until it forms a well mixed dough. If required, the dough can be chilled to make it firm enough to roll out. It is rolled out on a floured table to 0.25-0.5 cm thick and cut to the required shapes with biscuit cutters. Pastry bars assist in achieving a uniform dough thickness. Dough pieces are evenly spaced on a lightly greased baking tray, decorated as required (e.g. with sugar crystals, chocolate chips, raisins, nuts, crystallised fruits etc.) and baked for 6-10 minutes at 204^{o}C until light brown.

Biscuits have a longer shelf life than other bakery products and are packaged to prevent moisture pickup, to protect them from light, air and heat which would allow development of off-flavours due to rancidity of the fats and to protect against crushing.). Paperboard cartons covered with film (polypropylene, cellulose or polyester, but not polythene), glass jars or metal tins are all suitable packaging materials.

Cakes and scones

There are two main methods of making cakes: the ‘sugar-batter’ method (Table 5.5) and the ‘flour-batter’ method (Table 5.6).

There are hundreds of different recipes for cakes and each complies with three basic rules for cake making:
1. The weight of fat should not exceed the weight of egg
2. The weight of fat should not exceed the weight of sugar
3. The weight of sugar should not exceed the weight of total liquid

The effect of too much or too little of each ingredient is shown in Table 5.7.

Icings

Sales of cakes for birthdays, weddings, graduation ceremonies etc. to more wealthy customers in Kampala and other large towns can be highly profitable. When attractive and individual designs are made using icing, they are able to sell for several hundred dollars and thus offer very good opportunities to bakers to increase their income. A detailed description of the craft skills needed to make and use marzipan, icing sugar and gum tragacanth figures is beyond the scope of this manual and bakers should consult cookery books for these techniques

Table 5.4 Sugar-batter method of cake making

Stage In Process	Notes
Mix ingredients	Beat fat, margarine or butter with sugar to create a light foam. The time varies from 3 minutes using a high quality shortening, to 12 minutes for butter. Any colouring or essences should be added at this stage.
Mix	Mix lightly beaten egg into the sugar/fat cream in a steady stream over a period of about two minutes if a mixer is used, or if mixing is done by hand, in four portions, beating each one into the mixture in turn.
Mix	Mix sieved flour and baking powder and add carefully, folding it into the batter to achieve a smooth, lump-free batter without toughening it by too much mixing.
Mix	Carefully blend other ingredients (fruit, milk, nuts etc.) into the batter. The proportion of fruit in different cakes is for example: 55% in wedding cakes, 50% in birthday cakes, 45% in Christmas cakes and 20% in fruit cakes.
Bake	Pour batter into greased baking tins and bake at 182°C for 25 minutes or until the inside is properly baked.
Cool	To room temperature on cooling racks
Store	Store in a cool dry place away from sunlight.

Table 5.5 Flour-batter method of cake making

Stage In Process	Notes
Mix ingredients	Whisk sugar and egg together to form a batter. Any colouring or essences should be added at this stage.
Mix	Sieve flour to incorporate air. If the recipe uses margarine or butter this should be creamed with an equal amount of flour before mixing with the egg/sugar. Add the sugar/egg to the fat/flour mixture in about 4 equal portions, until smooth and free from lumps, causing as little disturbance as possible to the light structure.
Mix	Add sieved flour and baking powder, folding it into the batter to achieve a smooth, lump-free batter without toughening it by too much mixing. It is important that the two mixtures are at the same temperature.
Mix	Any remaining liquid, fruits, nuts or other ingredients are carefully blended into the batter.
Bake	Pour batter into greased baking tins and bake at 204°C for 25 minutes until the inside is properly baked.
Cool	To room temperature on cooling racks
Store	Store in a cool dry place away from sunlight.

Table 5.7. Effect of ingredients on cake quality

Ingredient	Purpose	Effect of too much	Effect of too little
Sugar	Sweetens and lightens the texture. Helps form the crust, develop the colour, improve the flavour and preserve the cake	Causes batter to over-expand and structure to collapse, brown sugar spots, open and sticky crumb.	Smaller cake volume and a 'pecked' crown, lack of bloom on crust and crumb too dense
Fat	Opens the texture, improves the eating quality and carries flavours.	Small cake volume, a thick and greasy crust, crumb is greasy and collapsed at the base	Poor crust colour, peaked top, smaller volume, tunnel holes in the tough crumb, will stale rapidly[1].
Milk	Moisten the cake and reduces lightness	Tough, rubbery texture. A heavy solid core at the base with a large hole above it[2], so cake collapses.	Lack of volume, tastes dry and stales rapidly.
Egg	Gives structure to the crumb	Tough, rubbery crumb	Not essential – no major effects
Baking powder	Produces carbon dioxide which raises and aerates the batter, to give honeycomb texture in the cake	Too much gas, which causes cake to collapse during baking. Dark crust and open textured crumb, discoloured near the base.	Loss of volume. (also due to old or badly stored baking powder)

(From: Opportunities in Milling and Baking, Fellows and Axtell, 2003. See Annex A)

[1] This is because the effect of the fat on the gluten is less and there is more resistance to expansion of the cake during baking. Steam therefore escapes more violently, tearing its way to the crown of the cake.

[2] When hot, this space is full of steam and remains expanded, but as it cools the cake collapses.

Pastries

Choux paste is used to make éclair type pastries that can be filled with many different types of sweet or savoury fillings or cream. Water, butter and salt are boiled together and the heat is then stopped while flour is added little by little with constant stirring. The mixture is then heated and beaten until it is smooth and it falls away from the side of the pan. It is allowed to cool and beaten egg is added to the mixture, beating all the time until the paste is smooth and shiny. It is then piped onto trays as 'finger' shapes for éclairs, or 'rounds' for profiteroles.

Flan/pie casings

Pastry casings for pies and savoury flans are made from savoury pastes prepared in one of three ways:

1 Cold water paste is used where the paste needs to be rolled out or cut out using a warm cutter (or 'die'). Equal amounts of fat and flour are mixed using the slowest mixer speed. Salt water is added until the batter has absorbed the liquid and the remaining flour is mixed in to form a paste. It should be allowed to rest before rolling out.

2 Hot water paste is used to form pie cases. The fat and flour are mixed together at the slowest mixer speed to form a crumb and boiling salt water is added, mixing until a paste is formed.

3 Boiled paste is used to make hand-raised pies. The water, salt and fat are boiled together and the flour is then added slowly with constant stirring and heating. It should be used hot.

Other pastries

- Short[3] (or 'shortcrust') pastry is used for flan casings, tarts and 'petits fours'. It is made using either the sugar/batter or the flour/batter methods (see cakes below). Granulated sugar should not be used because it forms dark spots on the surface during baking and spoils the appearance of the pastry. It is important to keep ingredients cool at all times, using a refrigerator if necessary and not to over-mix, which makes the pastry sticky. The pastry is carefully rolled out and placed in flan ring or baking tray and then baked until golden brown.
- Tart pastry is made by mixing flour and salt, lightly rubbing in fat and then slowly mixing water into the flour, starting at the centre, to make a stiff paste. It should not be rubbed too much or it becomes greasy and should be rolled out only once to prevent toughening.
- Flan pastry is made by sieving flour and baking powder together, adding margarine and mixing at slow speed to form a crumb. Then egg and sugar are mixed together until the sugar is dissolved and this is added to the crumb and mixed to a lump-free paste. The pastry is rolled out and placed on a greased baking tray with a flan ring on it, or in a greased flan dish. A piece of greaseproof paper is placed on the pastry and weighed down with baking beans or similar and it is baked at 215^{o}C until golden brown and filled with a sweet or savoury filling.
- Puff pastry is made by mixing flour with beaten egg and then adding water to make a stiff paste. It is rolled out thinly and small pieces of butter or margarine are laid on top. They are covered with the remaining flour, formed into a tube and rolled out flat again. This is repeated two or three times. Then one third of the sheet is folded over and the other third is folded on top. This is repeated three times, folding in different directions, to build up the alternating layers of fat and dough. It is refrigerated for 1-2 hours and then formed into shapes and baked at 261-275^{o}C. The pieces are filled with cream, or sweet or savoury fillings (e.g. vol-au-vents).

Scones

Scones are made by sieving flour and baking powder together and then rubbing in margarine to form a crumb. The remaining ingredients are added, mixing carefully to a smooth dough. Fruit can be mixed in carefully and the dough is dusted with flour, rolled out to the required thickness and cut into round shapes using a biscuit cutter. These are baked on a griddle (or hot-plate) until browned on each side.

Flat breads

Common unleavened breads in Uganda include roti and chapati, but there are a large number of other types that may find a market in restaurants and fast-food outlets (including pitta bread, pancakes and tortillas).

Pancakes

Batter-based products are made by mixing the ingredients to form a uniform batter and then pouring a portion onto a hotplate. After a few seconds, it is turned over and the other side is

[3] 'short' means that the pastry is easily broken and should not be at all leathery or tough.

baked. At their simplest, pancakes are made by mixing strong flour and water to form a thick batter. This is then poured in a thin layer on a griddle/hot plate or in a frying pan, with a little oil to prevent it sticking to the pan and heated until dry and brown. It can be rolled and filled with sweet fillings (cream, jam, honey, fruit etc.) or with savoury fillings (meat, fish or vegetables etc.). Variations on the basic recipe include adding egg or milk to produce a richer tasting pancake, or adding spices, such as cinnamon to the batter.

Tortillas

These are a type of pancake made using maize flour.

Table 5.8. Process for tortillas

Stage In Process		Notes
Mix ingredients		Boil together water and half of the butter
Mix		Slowly stir in maize meal until all is absorbed and then adding the remaining butter and mix to a smooth paste.
	Mix	Mix salt into flour
Knead ←	Mix	After cooling, add to the paste and knead to a soft dough
Form		Make into round balls and roll out to approximately 15 cm discs
Bake		On a griddle for 2-3 minutes on each side or until the surface is flecked with brown spots
Cool		To room temperature on cooling racks. If required, they can be filled with a variety of savoury fillings
Store		Store in a cool dry place away from sunlight.

Double-layered breads are made in a similar way, but they are given a second proofing of 5-10 minutes before baking. This allows the dough to relax, aerate and develop a thin skin. When they are baked in a hot oven (350-650^{o}C) for 18-100 seconds, the skin forms a crust and the steam inside the dough together with gas from the proofing, force the top and bottom crusts apart and creates two layers.

Checklist 5 a
Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer

Question	Tick	Notes
1. Do you know how to correctly prepare raw materials and process/pack the following products?		
• Bread		
• Buns		
• Doughnuts		
• Biscuits and cookies		
• Cakes		
• Scones		
• Pastries		
• Flan and pie casings		
• Flat breads and pancakes		
2. Do you know which of the above products have an increasing demand?		

Bakery equipment

The equipment required for a bakery is described in the following section. A summary of the spare parts that should be kept in stock and equipment maintenance requirements is shown in Table 5.9. Details of cleaning schedules are given in Sections 2 and 6.

Table 5.9, Summary of spare parts and maintenance requirements

Type of equipment	Spare parts kept in stock	Maintenance/cleaning required
Bread slicers	Blades	Cleaning each day
Deep fat fryers	None	Periodic (monthly) removal of oil and cleaning
General tools, work tables	None	Cleaning each day
Mixers	Shear pins	Cleaning each day
Moulding and forming machines	None	Cleaning each day
Ovens	None	None
Packaging machines	Heat sealer element	None
Provers	None	None
Scales	None	Cleaning each day

Wherever possible, it is better to buy equipment from local suppliers or engineering workshops because it should be faster and easier to have machines serviced or to obtain spare parts. Information on equipment suppliers is given in the UNIDO Food Processing Equipment Directory. If equipment must be imported, the following points should be considered when ordering it:

- Say exactly what is required (manufacturers may have a range of similar machines).
- Give the throughput required in kg or litres per hour and the type of food to be processed
- Where possible, give other information (model number of machine, single or three-phase power, number and types of spare parts required).

Information on overseas equipment suppliers is available at USSIA, UNIDO, UMA, at offices of development agencies, the Chamber of Commerce, Makerere Department of Food Science and Technology, UIRI, FOSRI (Annex A), or at embassies of exporting countries. Internet access can also be used to locate websites of equipment manufacturers.

All bakery equipment should be designed and constructed so that it can be easily cleaned. Any build-up of food in cracks recesses can contaminate later batches and risk causing food poisoning. In particular, mixing bowls should have a smooth internal surface without corners and all welds should be ground to a smooth finish. Mixing bowls and other preparation equipment should be made from stainless steel or plastic. The lack of stainless steel welding facilities in Uganda is a constraint on producing locally made bakery equipment and it is mostly imported from Kenya, South Africa or Europe.

The basic equipment needed in all bakeries is an oven, a mixer, a prover, weighing scales, containers for dough or batter, hand-tools (Table 5.10) and a work table. A dough divider and a biscuit moulder for cutting pieces of dough of equal weight, are also useful additional pieces of equipment.

Bread slicers

Manual bread slicing is not suitable for a commercial bakery - it is too time-consuming and the slices do not have a uniform thickness. Small electric bread slicers are the only option for bakers who wish to produce sliced bread. There are no spare parts or routine maintenance and crumbs should be cleaned from the machine every day.

Deep fat fryers

The simplest fryer is a pan of oil over a fire, but there is little temperature control and a risk of burning both the oil and the product. The equipment supplied is a more sophisticated version of this for use in rural areas. **Warning: the equipment does not control the temperature of the oil and there is a risk of fire if it is allowed to become too hot.** Thermostatically controlled electric deep fat fryers overcome these problems. They can be imported or made by local workshops. The fuel-fired fryer has no maintenance requirement and no spare parts. When the oil becomes darkened the fryer should be emptied, cleaned with detergent and rinsed with clean water.

Fig. 5.1 Deep fat fryer

Hand tools

All types of fruit and vegetable processing require basic equipment such as buckets, tables, stainless steel knives etc. to handle and prepare ingredients, dough and products. Aluminium or stainless steel sheet is the preferred material for the surface of work tables. However, wooden tables are more widely used because of the high cost of these metals in Uganda. Wood is more difficult to clean and if it is used it should be covered by a sheet of thick plastic, or a ‘melamine’ type surface. Food grade plastic should be used for all containers, rather than the yellow plastic containers that are widely available. Suppliers of food grade plastic vessels and metal tables are given in the UNIDO Food Processing Equipment Directory.

Table 5.10. Hand tools and small items of equipment used in a bakery

Hand-tools	Uses
Baking trays	Steel trays of various sizes for bread and flour confectionery
Biscuit cutters	For cutting shapes from rolled out dough sheets
Bread tins[1]	Single tins of various sizes for different sized loaves, or 'straps' of 3-6 tins joined together. Special shaped tins for speciality breads.
Buckets/bowls	Plastic, aluminium or stainless steel, for mixing ingredients
Cake hoops	A range of large tins for baking cake batter
Cake tins	A range of sizes for small cakes, pies or tarts, fluted or plain.
Cooling racks	For temporary storage of baked products before packing. May have wheels.
Dipping forks	For decorating cakes
Dough dockers	Spikes for puncturing the surface of dough or pastry
Dusting boxes	For shaking a thin layer of flour onto tables for dough kneading
Flour sieve	Wire or nylon mesh to remove large particles from flour
Funnels	To transfer liquids into narrow-necked containers
Glaze brushes	For brushing on milk or egg to give a glossy surface to products
Hard brushes	To remove compacted dough from floors
Knives	A set of cutting knives and a set of palette knives
Measuring jugs	For measuring correct volumes of liquid or powder ingredients
Nail brushes	To clean hands of operators
Oven gloves	To protect hands when handling hot baked products
Oven peel	A long-handled, flat shovel used to removed baked products from the oven
Pastry cutters	A fluted set and a plain set to cut shapes in pastry
Piping tubes/bags	For cake decoration, for depositing batter onto trays or filling products with cream
Pots and bowls	For temporary storage of ingredients
Rolling pins	For rolling out flat dough sheets
Sandwich tins	A range of larger tins for sponge cakes
Scales	0-1kg for minor ingredients, 0-50kg for weighing flour
Soft brushes	For clearing up flour and spilled ingredients
Spatulas	For stirring or beating ingredients
Storage bins	For bulk ingredients, baskets/trays for distribution of bakery products
Table scrapers	Metal scrapers for scraping mixing bowls or work surfaces
Table brushes	For keeping the work area clean
Thermometer	For testing dough temperature or oven temperature.
Waste bins	For hygienic temporary storage of waste materials.
Whisks	For beating batters

(From: Opportunities in Milling and Baking, Fellows and Axtell, 2003. See Annex A)

Ovens

The design of fuel-fired ovens should ensure that soot or ash from burning fuels does not contaminate products and that there is a free flow of hot air and gases from the firebox or burner to the oven. Gas ovens should have a failsafe device that cuts off the gas if the flame goes out. Electric ovens should be fully earthed and wiring should be properly insulated and routed in the oven so that there is no risk of electrocution from wiring that melts because of heat from the oven. In all ovens, the heat should be evenly distributed throughout the baking chamber and all parts of the chamber should be easily reached through the oven door so that products can be loaded/unloaded without the risk of burns.

Fig. 5.2 Oven

A well-designed oven should:

- Be easy to heat with only a moderate amount of fuel or electricity and lose little heat
- Have a uniform difference between the heat at the top and bottom of the oven
- Bake products uniformly without hot or cold spots
- Produce extra ‘top’ or ‘flash’ heat when required
- Produce baked goods that are clean and not contaminated by ash or smoke.

Another design feature is the ability to inject either steam or water into the oven if a product with a glazed crust is required.

There are two categories of ovens: those that are heated internally and those that have a separate heat source. In internally (or ‘direct’) heated ovens, an arched roof (or ‘crown’) contains stationary, very hot air that cannot escape through the door. This acts as a heat ‘reservoir’ which is radiated down to bake the products. They are simple and cheap to build, but the ash and smoke can contaminate the food. An externally (or ‘indirect’) heated oven has a baking chamber surrounded by flues leading from a firebox. Heat from the firebox passes along the flues through the brickwork and into the baking chamber, so keeping smoke, soot and ash away from products. These ovens operate continuously because the fire can be maintained without interrupting production. There are no spare parts or maintenance requirements, but ovens should be kept clean by removing burned on food (and ash in directly heated ovens).

Mixers

An electric mixer is needed for a profitable bakery operation. It must have the following features:

- flexibility to mix different types of products
- sufficient capacity for the expected production rate
- an hygienic design for easy cleaning (a hemispherical stainless steel or plastic bowl and a sealed motor/gearbox to prevent oil or grease from contaminating the dough)
- good mixing efficiency to mix a product in a short time with minimum energy consumption
- safety features to prevent operators trapping their hands in the mixer or receiving electric shocks.

Fig. 5.3 Mixer

Planetary mixers (Fig 5.3) with a bowl capacity of 20-50 litres are used in small-scale bakeries. The rotating blades include all parts of the bowl in the mixing action. Another design has fixed rotating blades that are offset from the centre of a rotating bowl. Both have a small clearance between the blades and the bowl so that food is continually scraped away by the blades. 'Gate' blades are used for pastes and creams, 'hooks' are used for doughs and 'balloon whisks' are used for cake batters or for whipping cream. There are no spare parts or maintenance requirements. Mixers should be cleaned by washing the bowl with detergent and rnsing with clean water.

Motors/isolators/starters

Motors should not be wired directly to 13 amp sockets and a starter and isolator should be fitted. When used, V-belts should be tightened to permit a maximum of 2cm sideways movement at the centre of the belt. There are no routine maintenance requirements, except to check that wiring a remains properly connected and does not work loose because of vibration. Motors, starters and isolators should be kept clean and the external surfaces should be wiped down weekly.

Always ensure that a motor is isolated from the mains before touching it for any reason.
Do not use water to wash any electrical equipment.

Provers

A prover is an enclosed cabinet, heated to 35-43^{o}C, with a relative humidity of around 85%. A simple prover can be made using a wooden framework, covered in polythene sheets and heated by a gently boiling pan of water inside the cabinet. Dough is placed on racks for the required proving time. One baker in Kampala[4] uses an old steel shipment container that is fitted with a steam pipe from a boiler located outside the container. The dough is loaded onto wheeled trolleys and the doors are closed while proving takes place. Stainless steel proving cabinets are electrically heated and give better control over the temperature and humidity, but they are expensive. There are no spare parts or maintenance requirements, but provers should be kept clean by routine weekly cleaning.

Packaging machines

Most products from small-scale bakeries are not packaged, except wrapped in simple paper or plastic bags to protect them from dust and other contaminants. A heat sealer can be used to seal plastic bags (Fig.5.4). Biscuits have a longer shelf life and are packed by hand in cartons with plastic inserts to hold the biscuits in place. The carton is covered with a moisture-proof and airtight film, such as cellulose, polyester or polypropylene and heat-sealed.

Fig. 5.4 Heat sealer

These machines simultaneously melt and press plastic to weld two layers together, thus sealing a bag. A small bulb lights when the bar is pressed down and the bar should be released about one second after the light goes out (to allow the film to cool). The manufacturer's recommended settings are shown in Table 5.2. To find the correct setting, the control should be set at the minimum number and the sealer used to seal a bag. If no seal is formed, the control should be set to a higher number and re-tested. This should be repeated until a strong seal is formed. If the plastic burns or holes are formed in the seal the setting should be reduced.

A sealing wire should be held as a spare. There is no routine maintenance and the sealer should be wiped clean weekly. Any burned-on plastic should be removed immediately by wiping the Teflon cloth and sealing bar using a cloth dampened with a suitable solvent (e.g. kerosene). If the Teflon cloth is torn, it should be replaced immediately because a torn cloth will short-circuit the heating element and damage it. The machine can be left plugged into the electric socket because it only uses power when the bar is pressed down.

Scales

Ideally, two sets of scales are used, one weighing up to 5 kg with an accuracy of +/-1g to weight small amounts of ingredients and a second weighing up to 20-50 kg having an accuracy of +/- 200g for flour. However, scales are expensive and it is cheaper and faster to replace smaller accurate scales with calibrated scoops, cups or other measures, which contain the correct quantity of an ingredient when filled level with the top. Operators should be trained to ensure that they use them properly to measure consistent weights. The scales have no spare parts or routine maintenance. They should be cleaned after use using a damp cloth

[4] With acknowledgement to Mr Abassi Musisi, Kampala Jellitone Supplies.

Sources of packaging and ingredients

Although most bakery products require only simple packaging to keep them clean, specialist plastic films for biscuits and other long shelf life bakery products are not available in Uganda and the only option is to import them from Kenya or South Africa. However, there is often a minimum order size that far exceeds the annual production capacity of a small-scale baker and this may prevent the manufacture of these products. Options include joint purchases of packaging by a number of bakers (a facility that could be organised by UCOFPA) or ordering via the Midway Centre (Annex A).

Most common ingredients that are used in bakeries can be obtained reasonably easily in Kampala. Bakers' yeast, baking powder, shortenings or oils and some types of food flavourings/colours, can be obtained from larger supermarkets. Other ingredients such as emulsifiers, gum Tragacanth (for icing decoration on cakes) anti-oxidants, stabilisers etc. are more difficult to find and may have to be imported by a special order.

Checklist 5 b

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.

Question	Tick	Notes
1. Do you know where to obtain the following equipment?		
Bread slicers		
Deep fat fryers		
General tools, work tables		
Grain conditioners		
Dehullers		
Mills		
Mixers		
Moulding and forming machines		
Ovens		
Packaging machines		
Provers		
Scales		
Seed cleaners		
2. Do you know how to clean the above equipment?		
3. Do you know how to maintain the above equipment?		
4. Do you know where to get spare parts for the above equipment?		

Bakery "Quality Assurance"

All cereal products should have a marketable quality and also be safe for consumers to eat. It is not possible to improve the quality of an ingredient by processing it and careful selection of reputable suppliers and simple quality assurance tests are needed to be sure that only the best raw materials and ingredients are used. Even at the smallest scale of production, millers and bakers should develop a Quality Assurance system to ensure this. The following steps are needed to develop a system:

1. Look at every stage of the process, from raw material selection to distribution of products and identify the factors (Critical Control Points) that could affect either product quality or safety.
2. Develop procedures to monitor and control these factors so that they do not cause a problem.

QA in a mill or bakery should:

- Identify all potential sources of contamination
- Use procedures to prevent contamination
- Identify process control points that can be used to ensure uniform products are routinely produced
- Ensure that product weights or package fill-weights are correct
- Ensure that products or packages comply with regulations on product descriptions and/or labelling regulations.

A QA programme should therefore include operator training in ingredient inspection, process control, cleaning schedules and control over packaging and distribution. The basis of QA is to prevent problems from arising, rather than trying to cure them afterwards. Factors that should be examined include the ingredients, particularly any spices that might be contaminated with micro-organisms and the amounts of any preservatives that are used. Additionally, any sources of contamination from buildings or water supplies should be included (Section 2). The stages in a process where an error could affect the safety of a product are known as Critical Control Points (or CCPs) and these are the stages that should be given most attention.

It is important to train all staff to operate the QA procedures that are devised. They should know the limits that are put on variations from specified processing methods and everyone should understand his or her responsibilities for ensuring that high quality products are made. The more staff that examine the raw materials, ingredients, process and product, the greater the level of control. It is also important to develop reporting procedures and keep records. There should be a plan of what must be done if the process limits are exceeded. Workers should know who has the authority to make decisions and who is responsible for checking that the correct action is taken. Once the factors that affect the quality and safety of the product are identified, steps can be taken to monitor and control them.

Worked example 14: establishing a quality assurance production system

In cake production, the stages in the process and factors to consider are shown as follows:

Mix ingredients	Ingredient storeroom and containers should be regularly cleaned and checked to ensure that stocks of ingredients retain their quality. Weights of each ingredient should be the same for each batch. Time of mixing and mixer speed should be standardised to give uniform batter consistency
Bake	The weight of batter should be the same in each baking tin. Oven temperature and baking times should be standardised to achieve uniform quality
Cool	Clean cooling racks as part of routine cleaning schedule.
Store	Ensure storeroom is cool, dry and dark, with good ventilation. Clean as part of routine cleaning programme.

QA systems should also monitor the time that raw materials and ingredients remain in storage. Records should show which materials are transferred into and out of the storeroom and when they are used or sold. Processors should also monitor and control distribution to retailers and storage/display in retail outlets. The Bureau of Standards can assist small businesses to implement QA systems. This type of assistance could also be organised by the Uganda Cottage Scale Food Processors' Association.

Quality assurance (QA) is used identify where problems (critical control points) may occur and prevent them before they occur, rather than trying to correct them afterwards. QA in a bakery should:

- Identify all potential sources of contamination and use procedures to prevent them
- Identify process control points that can be used to ensure uniform products are routinely produced
- Ensure that product weights or package fill-weights are correct
- Ensure that products or packages comply with regulations on composition and labelling.

A QA programme should check for contaminants by:

- Ingredient inspection
- Process control
- Operator training
- Cleaning schedules
- Control over packaging and distribution

Products such as pies that contain meat, fish or vegetables have a greater risk of containing food poisoning micro-organisms if they are not handled and stored correctly. The temperature danger zone is 10-45^{o}C and these products should spend as little time as possible at these temperatures during processing. Products that contain cream fillings should be stored below 5°C in refrigerators. Pies and samosas should either be chilled or stored in a hot display cabinet above 63°C.

Care and attention to safe food handling practices, temperature control and thorough cleaning is essential to produce these products safely.

Ingredient inspection

It is important to note that many of the methods described below can only be compared with other results obtained by the same method, but they cannot be compared to results found using a different method. It is important to ensure that exactly the same method is used each time.

Flour

Bakery storerooms should have the following management practices:

- Store sacks of flour on pallets away from walls, to prevent dampness and allow easy cleaning around and underneath the sacks
- Use stock rotation (first-in-first-out (FIFO))
- Ensure that the storeroom is dark, dry and cool without temperature fluctuations
- Ensure that the storeroom is sealed against insects, birds and rodents and that doors are not left open when not in use
- Clean the storeroom each week to prevent dust accumulating
- If affordable, use an insect electrocutor in the storeroom

Before use, flour should be checked to ensure that there is no visible mould growth and that it does not have a mouldy or rancid smell.

Flour infestation

Flour mites are common in mills that are not properly cleaned and can be detected as follows:

- Place 100 g of flour onto a flat surface and use a ruler to spread it out and flatten it.
- Examine the flour for evidence of pimpling (disturbance of the surface) after about two minutes. Pimpling shows that live flour mites are breaking the surface for air.

The Filth Test detects dead flour mites, insect parts, rodent hairs or faeces in flours.

- Stir a sample of flour with petrol in a glass jar.
- When the suspension settles, contaminants can be seen floating on the surface of the petrol. They may be filtered out and identified.

Moisture content

1. Accurately weigh (+/- 0.001 g) triplicate 2 g samples of flour into small dishes and place them in an oven at 100^{o} C for 4 hours (or 104^{o}C for 2 hours)
2. Remove, put into a desiccator to cool and re-weigh
3. Replace the dishes in the oven for 30 minutes and repeat the process until their weight does not change.

4. Calculate the moisture content using the following formula:

$$\% \text{ moisture} = \frac{\text{initial weight} - \text{final weight}}{\text{initial weight}} \times 100$$

Water absorption

Good quality bread flour absorbs water to 60-65% of the weight of the flour and biscuit flour to 55%. Too much absorbed water gives a sticky dough and too little produces a tough, product. This test can be used to indicate a wrong grade of flour or to compare new batches of flour with an existing supplier.

1. Weigh 100g of flour into a mixer bowl
2. Add water slowly to make a standard dough (judged by the baker to 'feel right').
3. Record the amount of water added

Gluten measurement

The gluten content of flour can be checked by washing out the starch from dough and examining the gluten that remains. With experience, a baker can quickly tell strong from weak flour.

1. Weigh 10g of flour into a bowl
2. Add 6 ml of water (5 ml for weak flour).
3. Mix into a dough and form the dough into a ball
4. Place the ball in the basin, cover it with water and leave for 45-60 minutes (if a rapid result is needed leave it for at least 10 minutes)
5. Wash out the starch under cold running water, squeezing the dough frequently to help remove the starch. When all the starch has been removed the water will run clear and the remaining gluten will be free of lumps.
6. Remove excess water with a cloth or tissue paper
7. Weigh the gluten and record this as a percentage of the flour weight (for a strong flour it should be 12-13% and for a weak flour 9-10%)
8. Assess the strength and elastic properties of the gluten by pulling the piece apart and observing how much it stretches and its breaking point.

Starch gelatinisation

Gelatinisation of starch granules in flour is caused by moderate heat and moisture and increases the viscosity of the starch paste. The degree of breakdown of starch granules is controlled to give different baked products. The following test assesses the viscosity of gelatinised flour by measuring the time that a steel ball takes to drop through it.

1. Mix 100 g of flour with 900 g of hot water in a bowl
2. Heat until the flour has gelatinised and the paste begins to clear
3. Pour the mixture into a tall vessel (e.g. a measuring cylinder), which is stood in hot water
4. Drop a small steel ball into the mixture and record the time taken for it to drop 200 ml
5. Compare the time to a standard flour.

Fats and oils

Solid shortenings (fats) should be routinely checked by smell and taste and any rancid fat should not be used. They should be stored in a cool place away from sunlight, preferably in a refrigerator and used as quickly as possible with strict stock rotation. Oil is usually delivered in tins, which protects it from air, heat and moisture pickup and prevents the development of rancidity. Provided the tins are kept sealed and the store is reasonably cool, there should be few quality assurance problems. If oil from village producers is delivered, containers that do not adequately protect it, the oil should be checked for rancidity by smelling or tasting it. All oils should be clear and without sediment.

Salt and sugar

Generally these ingredients both require little testing, but they may contain dust and dirt. This is assessed by dissolving a small amount in hot water and allowing any dirt to settle.

Yeast

Dried yeast has a shelf life of 1-2 years provided it is stored in an airtight container in a cool dry place. Fresh yeast must be stored in a refrigerator if it is to be kept for more than a few days, but even at this temperature, it begins to lose its activity after a few weeks. To test yeast activity, a standard ball of dough is placed in water and timed to see how long it takes for the yeast to inflate the dough and float to the surface.

1. Add 5g of yeast to 100g of water to form a suspension
2. Weigh 3 g of flour into a pot and mix in 1.8 g of the suspension
3. Mould the dough into a ball and place it into a narrow pot containing 150 ml of water at 25°C.
4. Place the pot in a water bath at a constant temperature of 25°C.
5. Measure the time from placing the ball in the pot until it floats to the surface.

Other ingredients

Bakery premixes should be stored as recommended by the manufacturer; essences and colours are supplied in small glass bottles and should be stored away from sunlight in a cool place. There are no quality tests that are normally required on these ingredients.

Process control

Process control involves accurate weighing of ingredients, control over temperatures and times and correct handling procedures. The checks required at the main control points for bread production are shown in Table 5.12. Bakers should produce a similar schedule for all products that they produce. The weighing scales, thermometers and timers that are used for process control should be handled carefully and regularly checked for accuracy.

Table 5.12. Process control points for bread production

Process stage	Control points
Raw material reception	Inspection and testing (see text)
Mixing	Correct type and weight of ingredients, dough temperature, yeast activity
Proofing	Time, relative humidity and temperature in proofing cabinet
Dividing and knocking back	Size/weight of pieces, extent of knocking back
Intermediate proofing	Time, temperature, relative humidity in the proofing cabinet.
Knocking back	No specific controls, consistent procedure used
Final moulding	Gentle moulding to create a uniform structure having small bubbles
Final proof	Temperature, relative humidity and time in prover
Baking	Time, temperature (and humidity for some products) in the oven.

Cleaning schedules

Each operator in a bakery should know what to clean, how often and to what standard. The manager should produce a list of equipment and the different areas in a bakery and indicate how often they should be cleaned and who is responsible. Safe, potable water must always be used to clean equipment. To avoid the risk of residual contamination, the use of detergents and disinfectants should be minimised.

Assessing products

The majority of bakery products are assessed by simple visual examination as they are produced. However, the weight of bread should comply with the law in Uganda and sample loaves should be check-weighed.

Loaf volume measurement

Loaf volume is an important characteristic that customers look for and a baker can assess this using a device that measures the displacement of rapeseed or mustard seed. A given weight of seed always occupies the same volume. The measuring equipment can be constructed locally and consists of two rectangular compartments, connected by a graduated glass or transparent plastic cylinder. Seed is placed inside and flows from one compartment to the other as the apparatus is inverted. The tube is calibrated by using the equipment with objects that have known volumes (e.g. carefully measured baked clay bricks of different sizes). With the seed in the lower compartment, the test loaf is placed in the top compartment and the apparatus is inverted so that the seed fills the space around the loaf and levels off in the tube. The loaf volume (in cubic centimetres) is read from the graduations on the tube.

Crumb firmness and springiness

A method of checking the freshness of bread is a squeeze test to measure crumb recovery (i.e. degree of crumb springiness or resilience). An assessment is made of how much the loaf returns to normal after squeezing it. A good quality loaf should have >50% recovery.

Crust and crumb colour

This is assessed against colour standards (e.g. painted cards) to indicate golden brown, pale crust, burnt crust uniformly white crumb etc.

Crumb structure and stability

The size and shape of cells, thickness of the cell walls and the evenness of the cells are assessed. A baker's judgement of these characteristics relies on experience and knowledge of the product.

Rope and moulds

"Rope" is a sticky material that can be pulled into strings when a loaf is broken open. The micro-organism that causes rope can be present in flour, water and yeast. It can be controlled by using good quality ingredients, thorough baking and followed by rapid cooling of the loaves on slatted shelves to allow air to dry the bottom of the loaves. They should not be packed close together while cooling so that air can pass between them. Proper cleaning of equipment, water tanks and surfaces and good personal hygiene are all needed to prevent rope.

Different types of mould also spoil bread. They grow in damp conditions and bakery products should therefore always be stored in a cool dry place. Mould contamination can be controlled by:

- Strict bakery hygiene, including regular cleaning of equipment
- Removing all wastes, flour dust and stale food, each of which can harbour mould spores
- Using a vacuum cleaner to remove dust from floors rather than a brush which makes it airborne and allows spores to contaminate equipment and ingredients
- Preventing airborne dust from entering the bakery from outside
- Preventing dampness in storerooms.

Packaging, storage and distribution

Short shelf life baked goods can be wrapped in paper or polythene film. If protection against crushing is important (e.g. for cakes, pastries and pies), products can be packed in cardboard cartons or loaded onto trays for transport. In each case the only quality assurance procedures are to ensure that the packaging is clean and products are handled carefully. Biscuits require more sophisticated packaging to ensure a shelf life of more than 3-4 months in Uganda's climate. QA procedures are required to:

1. Ensure that the packaging is made of the correct type of plastic and has the required thickness
2. There are no holes, tears or punctures in the film
3. The seal is correctly formed and has the required strength

Stores used for baked products should be cool, dry, regularly cleaned and protected against insects and rodents. Mobile racks are easy to inspect and assist stock rotation. Slotted high density polyethylene or polypropylene trays are easily cleaned and stacked. Similarly, mobile plastic or stainless steel ingredient storage bins keep materials clean, restrict contamination by insects and rodents and can be wheeled to the point of use.

Correct stock rotation using the 'first in first out' (FIFO) system prevents unnecessary wastage. Short shelf life products should be checked daily and weekly checks should be made on other products and on raw materials. Stock rotation is easier to operate using date coding, but most bakery products do not legally require a sell-by date. Bakers can use their own code (e.g. blue for Monday, red for Tuesday etc.) to identify the date of production.

Table 5.13 Frequency of Quality Assurance checks

Daily
Check weight and condition of raw materials
Check processing conditions and machine settings
Check for loose parts on machines
Check fill weights and quality of seals
Clean the production equipment and factory, including toilets and washrooms. To avoid residue contamination, cleaning programmes for equipment should minimise the use of detergents and disinfectants.
Weekly
Check equipment for worn parts that could fall off and contaminate products or damage machines
Clean storerooms and other non-production areas
Send work clothes for washing
Check stocks for signs of damage or theft
Monthly
Clean windows
Check and service machinery
Check walls and floors for cracks
Do full stock check of ingredients and packaging materials
Check testing equipment to ensure it is accurate
Yearly
Review QA procedures, staff training and recording systems to ensure that they remain appropriate to the needs of the business.

Checklist 5 c Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.		
Question	**Tick**	**Notes**
1. Do you have schedules for routine inspection and cleaning of the bakery?		
2. Does your processing room meet legal requirements for hygiene and sanitation?		
3. Do you know how to test your products?		
4. Do you know how to check your packaging?		
5. Do your products meet legal requirements for product specification?		
6. Do your products meet legal requirements for fill-weight and label design/ information?		

6 Summary of Legislation and Regulation

International

Global efforts to establish and improve consumer health protection have led to increased governmental and regulatory oversight in the field of food safety. While most people presume the foods they eat are safe, several recent food safety events have eroded this confidence and led to demands from the public for additional protective measures to be enacted to establish the rights of consumers to safe food. The scope of this protection has expanded beyond the practices of the food manufacturers and now extends all the way back to the farm gate. It is essential that safety be embodied in food products from production through consumption, from the farm to the table (food chain approach). All stakeholders in the food chain, including the supply side (producers, transporters, processors and merchants), the government inspection and regulatory authorities, the support institutions (labs, R&D and training centres) and consumers will now have responsibilities and obligations to ensure the safety of food products and protect consumer health.

For enforcement purposes, the Codex Commission has developed several guidelines and food standards. There are today approximately 250 standards and specific requirements for individual foods, groups of foods and other provisions, e.g., hygiene, contaminants, labelling and food additives.

Enforcement of food control has evolved from the traditional focus on inspection of final products and removal of unsafe food from the market to the current holistic and preventive approach, which relies more on system control. In addition to the traditional GMP (or GHP), formalized control operations relying on hazard analysis and risk prevention have been made mandatory in the main markets. This systematic approach to the identification, assessment and control of hazards is known as the Hazard Analysis and Critical Control Point (HACCP) system.

The introduction of a HACCP-based food safety system may be difficult for small-scale enterprises and will be best achieved by coordination between the food industry, educational and training organisations and governing authorities. There are various guides and training information on the introduction and application of HACCP in the food chain.

Uganda

At the time of the preparation of this manual in 2004, the Government of Uganda was in the process of developing the National Food Safety Strategic Plan. The Parliament was also debating a draft Food Safety Bill. Once enacted, the “Food Law” or the “Food Safety Law” will contain provisions for the mandatory implementation of GMP and/or HACCP programmes within the food chain. This law was proposed to develop an effective national food safety control system to protect the health and wellbeing of consumers, as well as, meeting international standards and requirements for the trade of food products. Uganda has also become the first East African country to launch a national programme to enrich processed foods with vital nutrients to boost consumer health. The Ministry of Health just announced the National Food Fortification Programme in July 2004. UNBS is in the process of drafting a “Foods Fortification Regulations and Standards” policy.

There are various laws governing the setting up, registration and operation of a mill or bakery in Uganda. Failure to follow the law may lead to punishment by the authorities or closure of the business. Millers and bakers should check the local laws with the Uganda National Bureau of Standards (UNBS). In summary the registration of a mill or bakery involves the following:

- Registration of the enterprise with the Ministry of Trade and Industry
- Obtaining a Certificate of Share Capital (for limited companies), or a Certificate of Incorporation (for corporate companies)
- Obtaining an Occupational Certificate from Local Authority, or the Planning Authority in the Land Ministry
- Obtaining a Health Permit or Licence from the Local Authority or Ministry of Health to allow the premises to be used for food production
- Obtaining a Manufacturing Licence, issued by the Local Authority or Ministry of Health
- Obtaining Medical Certificates from the Health Authority to certify that workers are fit to handle food
- Registration with the Revenue Office or Tax Office

Food regulations and standards

In Uganda there are both general regulations that apply to all foods and also standards that are specific to a particular types of food. UNBS should be consulted on details of the general regulations concerning:

- Labelling
- Presentation and advertisements
- Weights and measures and
- Hygiene practices during processing and handling
- Food Fortification Regulations and Standards

Millers and bakers should contact either the Ministry of Health or the Ministry of Agriculture, Animal Industries and Fisheries for details of laws relating to public health, food safety and hygiene and sanitation in their premises. Please note that Parliament is considering passage of a Food Safety Bill or Law that will complement the Food Safety Strategic Plan and have broad-ranging impacts on all participations in the food chain. Small-scale operators must remain in contact with the relevant enforcement agencies to remain in compliance with the Food Safety Bill or Law.

Flours

Laws specify the maximum residue limits for pesticides etc. in grains and millers should contact UNBS for details. The moisture content of flour cannot exceed 15% and the grade is specified by the allowable percentage of bran.

Labelling

Packaged flour should be labelled with the name and address of the miller and the name of the flour (not the brand name but the type of flour (e.g. 'maize flour')). Flours do not require date marking (e.g. 'Best before' or 'Sell by') if they are expected to have a shelf life of more than 12 months.

Weaning foods made from cereal-legume mixtures should conform to specifications of the Protein-Calorie Advisory Group of the United Nations (see Annex A). As a minimum, the label on weaning food containers should have a clear set of preparation instructions in the languages spoken by customers and diagrams to illustrate the preparation procedures, how often to feed the product and how much to give the child. Label instructions should be fully tested among consumers of all education levels and cultural backgrounds to ensure that they are properly understood.

Nutrition information on a label may also include a full list of vitamins and minerals, especially the salt content. A label can be used to make claims about the benefits of a specific type of flour, but such claims are illegal if there is a risk that they could give false or misleading information. Claims that are not allowed include those that say a food is: wholesome', 'healthful', or can 'cure disease'.

Bakery products

There are no legal limits on the amounts of flour, shortening, salt, milk or sugar in bakery products. Standard bread should have a maximum of 38% water, 3% non-wheat flours and 0.25% yeast (each is a % of flour weight). Other ingredients used in bread, such as soy-flour, poppy seeds, caraway seeds, cracked wheat or oatmeal, are specified to not exceed 2% by weight of the flour. Brown bread should have at least 0.6% fibre. Other speciality breads should have a certain percentage of a specified ingredient. For example:

Enriched bread	not less than 3% added fat
Milk bread	not less than 3.6% added whole milk solids or skimmed milk solids
Wheat germ bread	not less than 10% added wheat germ
Gluten bread	not less than 16% and not more than 22% protein
High protein bread	not less than 22% protein
Fruit bread	not less than 6% added fruit
Malt bread	not less than 6% added malt

Labelling

Unpackaged bakery products or those that are only packaged for direct sale to the consumer do not require labelling. However, the name that is used to advertise these products in a retail outlet should accurately reflect the product. Pies and samosas for example, should be described with the generic name of the ingredient (e.g. 'fish' or 'meat') or flans or pastries ('cream', 'fruit', 'cheese', 'nuts' etc.) to indicate the type of materials. It is not necessary to indicate the actual type of meat, fish or fruit that is used.

Bread should only be described using one of the following names:

- White bread
- Brown bread
- Wholemeal bread
- Wheat germ bread
- Wholemeal bread
- Soda bread
- Granary bread.

Packaged goods that have a long shelf life should indicate on the label the name and address of the producer, the type of product and a complete list of ingredients, starting with the largest amount and ending with the smallest amount. It is not necessary to indicate the actual amounts of ingredients used. Water that is used to make biscuit dough does not need to be included as an ingredient as it is less than 5% of the product weight, but should be included in other products if it is above 5%. Likewise, any additive that is used only as a processing aid and has no function in the final product need not be included (e.g. carbon dioxide produced by yeast during bread-making). Essences do not need to be individually identified, but simply reported on the label as ‘Flavourings’.

If there are compound ingredients (i.e. an ingredient is composed of two or more ingredients) these can be listed either as a single list:

Chocolate biscuits
Ingredients: Wheat flour, sugar, vegetable fat, cocoa powder, skimmed milk powder, starch, soya flour, salt, flavourings

Or divided into the different ingredients:

Pizza
Base: Wheat flour, water, animal fat, yeast, salt
Topping: Tomatoes, cheese, vegetable oil, spices

A compound ingredient need not be named if it less than 25% of the finished product (e.g. jam filling in a sponge cake).

If a producer wishes to use the European system of ‘e-numbers’, to identify additives, the code numbers can be obtained from offices of the European Union or CDE in Kampala. The ingredient list must show a category name, such as ‘preservative’, ‘colour’ or ‘emulsifier’ before the e- additive or number (for example: ‘Acidity regulator – sodium citrate’ or ‘raising agent – E450a’)

The label must show the net quantity contained in the pack (not including the weight of the packaging). Unwrapped bread is not labelled, but the law controls the weight of standard loaf sizes. Loaves must weigh 400g or a multiple of 400g.

Products that have a shelf life of less than 12 months, or other products such as pies that are sold in packages and intended to be eaten after a few days’ refrigeration require a date mark on the label Other bakery products do not require date marking if they are normally eaten within 24 hours, even if they are packaged.

Checklist 6 **Tick the box if you know the answer to each question, or write notes on what you need to do to find the answer**		
Question	**Tick**	**Notes**
1. Does your processing room meet legal requirements for hygiene and sanitation?		
2. Do you know how to test your products?		
3. Do you know how to check your packaging		
4. Do your products meet legal requirements for product specification?		
5. Do your products meet legal requirements for fill-weight and label design/ information?		
6. Do you know the basic requirements of the Food Fortification Regulations and Standards and how they impact your business? Do you know how to contact UNBS for information?		
7. Do you know the basic requirements of the new Food Safety Law and how it impacts your business? Do you know how to contact the Ministry of Agriculture, Animal Industries and Fisheries for information?		

Annex A: Sources of further information and assistance

The following organisations may be able to help solve specific problems, offer advice or information:

- Action Aid, 2514 Gaba Rd, Kampala, T: 266640
- ADC (Agribusiness Development Centre), PO Box 7856, 18 Prince Charles Drive, Kololo Kampala, T: 255482/83/68, F: 250360, E-mail: adc@starcom.co.ug
- AEATRI (Agricultural Engineering and Appropriate Technology Research Institute), PO Box 7144, Kampala, Email: aeatri@starcom.co.ug
- Aga Khan Foundation, 4 Parliament Ave, Kampala, T: 256165/ 255884
- ATI (Appropriate Technology International), 22a Namirembe Rd, Kampala, T: 349147
- Austrian Development Corporation, 6 Entebbe Rd, Kampala, T: 233002
- DIFD (Department for International Development - UK Govt), PO Box 7070, Rwenzori Building, Kampala, T: 348731/33, F: 348732, E-mail: info@dfid.gov.uk
- Department of Industrial Art and Design, Makerere University, PO Box 7062, Makerere Kampala, T: 531423, E-mail: fineart@imul.com
- DFST (Department of Food Science and Technology), Makerere University, PO Box 7062, Kampala, T/F: 533676, E-mail: foodtech@infocom.co.ug
- Department of Food Science, Uganda Polytechnic Kyambogo, PO Box 26486, Kampala, T: 285211
- Department of Home Economics, ITEK (Institute of Teacher Education, Kyambogo), PO Box 1 Kyambogo, Kampala, T: 285001/2, F: 220464, E-mail: itek@starcom.co.ug
- European Development Fund - Microprojects Programme, 24b Lumumba Ave, Kampala, T: 230033/ 35, 254613, 232487
- FAO (Food and Agriculture Organisation), 72 Buganda Rd, Kampala
- FIT Programme, P. O. Box 24060, Kampala, T: 221785, F: 221038, Email: fituga@imul.com
- FOSRI (Food Science and Technology Research Institute, part of NARO), PO Box 7852, Plot M217, Nakawa Industrial Area, Jinja Rd, Kampala, T: 222657/285248/077 594980, F: 222657, E-mail: fosri@imul.com
- Gatsby Trust, Faculty of Technology, Makerere University, PO Box 7062, T: 531048/545029, 077 408762, F: 542377, e-mail: gatsby@techmuk.ac.ug
- German Development Services, 1773 Muyenga, Tank Hill, Kampala, T: 268662/0
- KARI (Kawanda Agricultural Research Institute), PO Box 7065, Kampala, E-mail: karidir@starcom.co.ug
- IITA (International Institute for Tropical Agriculture), Marketing and Post Harvest Research East and Central Africa, PO Box 7878, Bandali Rise, Bugolobi, Kampala,T: 220217/077 472103, F: 23460, 223459, E-mail: foodnet@imul.com
- MAAIF (Ministry of Agriculture, Animal Industries and Forestry), PO Box 102, Berkeley Lane, Entebbe, T: 20980/3/8
- Midway Centre, c/o MTAC (Management Training and Advisory Centre), PO BOX 24050 Jinja Road, Nakawa, Kampala, T/F: 223505, E-mail: midway@imul.com
- Ministry of Health, PO Box 8, Kitante rd., Kampala T: 20209/0, F: 20474
- MUBS (Makerere University Business School, Business Development Centre), PO Box 1337, New Port Bell Rd, Kampala, T: 223859, F: 221682, Email: commerce@starcom.co.ug, commerce@infocom.co.ug
- NAARI (Agriculture and Animal Production Research Institute), PO Box 7084, Namulonge, E-mail: naari@naro.bushnet.net
- NARO (National Agricultural Research Organisation, Kawanda), Post Harvest Research Programme, Kawanda Agricultural Research Institute, PO Box 7065, Kampala, T: 567708, F: 567649, E-mail: karihave@starcom.co.ug
- NARO (National Agricultural Research Organisation) and FOSRI (Food Science Research Institute), PO Box 7852, Kampala, F: 222657, Email: fosri@imul.com
- Nile Vocational Institute, PO Box 1829, Njeru, Jinja, T: 22389/22019

- PRESTO, PO Box 24204, Plot 21 Kawalya Kaggwa Close, Kololo, Kampala, T: 347481-3, F: 347635, E-mail: presto@imul.com
- PSF (Private Sector Foundation), 3 Kintu Rd. Kampala, T: 342163, F: 230956
- Redd Barna, 42 Bwala Hill, Masaka or 4105 Libuba Katwe, T: 21015, 268675
- Sasakawa Global 2000, Ruth Towers, PO BOX 6987, Kampala, T: 345497, F: 346087, E-mail: sguganda@starcom.co.ug
- SCF (Save the Children Fund), 5 Baskerville Ave, Kololo, Kampala, T 344796, 258815, 343486
- Small Enterprise Development Company41 Oboja Rd, Jinja and 20 Kazooba Rd, Kabale, T: 21997
- SNV (Netherlands Development Organisation), PO Box 8339, 36 Luthusi Rise, Bugolobi, Kampala, T: 220584/2, 220780
- Ssemwanga Centre For Agriculture and Food, 47b Upper Kololo Terrace, Kampala, PO Box 40257, T: 346246/075 694612, F: 346246, E-mail: ssemwang@swiftuganda.com
- UMA (Uganda Manufacturers Association), PO Box 6966, Lugogo Showgrounds, Kampala, T: 220285/ 221034, F: 242455
- UIRI (Uganda Industrial Research Institute), Nakawa Industrial Estate, Plot M217 Jinja Rd, Kampala, PO Box 7103, T: 286245/077 406502, F: 285689,
- UNBS (Uganda National Bureau of Standards), PO Box 6329, Plot M217, Nakawa Industrial Area, Kampala, T: 222367/9, F: 286123, E-mail: unbs@starcom.co.ug
- USSIA (Uganda Small Scale Industries Association), PO Box 7725, Lugogo Showground, Kampala, T: 221785, F: 221038, E-mail: ussia@starcom.co.ug. Also PO Box 2344, Mbale
- VTI (Vocational Training Institute), PO Box 20121, Nakawa, Kampala, T: 20935/220028/236864

Engineering workshops

- Mr Kigongo-Kawesi, Tree Shade Technology Services, Bombo Road, Kampala, P O. Box 5833, T: 567698, F: 567698
- Mr Baljit Singh, JBT Engineering, Old Kampala, PO Box 11991, Kampala, T: 531339/077 488137
- Mr Bernard Bosso, Mechanical Engineering Department, Uganda Polytechnic Kyambogo, Kampala
- Mr Douglas Serroul, Adtranz, (Uganda Railways Mechanical Workshop), Nalukolongo, Masaka Rd, Kampala, T: 200580, F: 256047, E-mail: adtranz@infocom.co.ug
- Mr Fred Mukasa, Steelex, Bombo Road, PO Box 1765, Kampala, T: 567950

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Books, publications and information on milling, baking and baking products and ingredients can be found at:

- www.chipsbooks.com/listbak.htm
- www.preparedfoods.com (ingredients and recipes from magazine articles)
- www.bakingbusiness.com (bakers dictionary, the Encyclopedia of Baking and the Bakers Production Manual)

Professional Bakers Associations – free information, books and materials can be found at:

- American Institute of Baking, www.aibonline.org
- National Association of British and Irish Millers, www.nabim.org.uk/index.asp
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Annex B: Baking Glossary

Term	Definition
Aflatoxins	Poisons produced by certain types of moulds in cereals, nuts etc.
Baking beans	Small pieces of ceramic, shaped like beans, used to hold pastry flat in a tin during baking
Baking powder	A mixture of chemicals (cream of tartar and sodium bicarbonate) which react with moisture to produce carbon dioxide gas and aerate batters or doughs
Bran	The layer of material below the outer hull of grains and the germ
Carbon dioxide	The gas produced by yeast and chemical aerating agents in bakery products
Cream of tartar	One of the acids used in baking powder
Crown	The top of an oven
Crumb	The part of a bakery product other than the crust
Crust	The hard outer part of a baked product
Divider	A machine that cuts dough into pieces of equal size
Ferment	1. To produce carbon dioxide and alcohol (by the action of yeast) 2. A fermented mixture prior to being made into dough
Flash heat	Fierce heat in a coal-fired oven shortly after firing before the heat is absorbed by the walls
Gelatinisation	Changes to starch during heating in water in which the cells burst and a gel is formed
Germ	The oil-rich part of a grain from which the plant develops
Gluten	Wheat proteins that give structure to bakery products
Hard flour	Flour made from wheat that contains a high percentage of gluten
Hotplate	Heated flat metal surface used to bake products such as scones
Hulls	The outermost covering of grains
Improvers	Chemicals that are added to dough or batter to improve its quality or shelf life
Knead	To work dough by vigorous mixing
Knock back	To expel gas from dough by kneading
Marzipan	A paste made from sugar and almonds
Milled rice	Rice that has the husk, germ and bran layers removed (also known as 'white rice' or 'polished rice'
Mite	A small insect found in flour
Moulder	A machine to shape pieces of dough
Oven spring	Rapid expansion of dough when placed into an oven
Paddy	Unprocessed rice containing the husk
Parboiling	A process of steaming or soaking grain in hot water, followed by drying
Potable water	Water that will not cause illness
Prove	Aeration of dough by yeast
Prover	Cabinet in which fermented doughs are proved before baking
Relative humidity	A measure of the amount of moisture in air
Ripening (gluten)	The softening and conditioning of dough during fermentation
Rope	A fault in bread that results in a sticky crumb that can be pulled into strands
Shortening	Bakery fat
Skinning	Formation of a surface crust on dough or egg white when left uncovered
Sodium bicarbonate	The component of baking powder that reacts with acid to produce carbon dioxide
Soft flour	Flour made from wheat that contains a low percentage of gluten
Strong flour	Flour containing a high percentage of gluten
Tart	A pastry case containing a sweet filling
Weak flour	Flour containing a low percentage of gluten