Opportunities in food processing

Setting up and running a small flour mill or bakery

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CTA's tasks are to develop and provide services that improve access to information for agricultural and rural development, and to strengthen the capacity of ACP countries to produce, acquire, exchange and utilise information in this area. CTA's programmes are designed to: provide a wide range of information products and services and enhance awareness of relevant information sources; promote the integrated use of appropriate communication channels and intensify contacts and information exchange (particularly intra-ACP); and develop ACP capacity to generate and manage agricultural information and to formulate ICM strategies, including those relevant to science and technology. CTA's work incorporates new developments in methodologies and cross-cutting issues such as gender and social capital.

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Preface

This handbook is the result of a collaborative effort by small business owners and advisers of small-scale food processors in ACP countries. The effort was supported by the ACP-EU Technical Centre for Agricultural and Rural Cooperation (CTA). The information contained in the handbook was gathered by the researchers cited below, and prepared by Midway Technology consultants. The following specialists reviewed the draft publication and made valuable contributions to the text from the perspectives of their own countries:

- Dave Harcourt, FOODTEK, Council for Scientific and Industrial Research, Pretoria, South Africa
- Matano Kordawa, Hot Loaf Bakery, Kampala, Uganda
- Trevor Marshall, Thomas Danby College, Leeds, UK
- Dr Paul Bom-Konde, CIRAD-SAR, Montpellier, France

We hope this handbook will meet the needs of small-scale millers and bakers, by providing technical and business information that was previously difficult to find and by helping entrepreneurs to update and improve their businesses for the benefit of their consumers and, of course, their own profitability.

If you find this handbook useful, please take a few minutes to complete the feedback form at the end of the book. Your comments and suggestions will be used to improve the later books in this series.

The Editors

About the authors and researchers

Barrie Axtell is a British food technologist and a director of Midway Technology. He has 30 years' experience working in Africa, Asia and Latin America. His particular interest centres on small-enterprise-based drying of fruits and vegetables and processing high value crops such as medicinal plants, spices and essential oils. He has co-authored 15 books on the role of appropriate technology in food processing.

Dr Peter Fellows is a consultant food technologist and a director of Midway Technology. He is Visiting Fellow in Food Technology at Oxford Brookes University in UK and has held the United Nations Educational, Scientific and Cultural Organization (UNESCO) Chair in Post-Harvest Technology at Makerere University, Uganda. He is an experienced author and has published 12 books and more than 30 articles on small-scale food processing. He has had practical experience in 20 countries of the food processing industry and the institutions that support it.

Linus Gedi has experience in agro-industry and particularly in post-harvest technology. Before becoming a consultant he was first a tutor and then head at Illonga Agriculture Training Institute in Tanzania. For the past 17 years he has worked on various consultancy assignments, ranging from planning primary crop production, handling, storage and marketing of food products, project appraisal and evaluations. His commodity expertise includes cotton, cashew, sisal, oilseeds, grains, fruits and vegetables, beverages, fish and meat products. Since 1996 he has worked as the United Nations Industrial Development Organization (UNIDO) National Expert in food technology, training women entrepreneurs and trainers and helping set up enterprises that achieve high quality production and a cleaner environment.

Henry H. Lubin has been Produce Chemist with the Ministry of Agriculture, Saint Lucia for 20 years, conducting investigations into the utilisation of agricultural produce. During this time he has assisted and advised agro-processors on product development, quality and food safety and he also conducts chemical analyses on foods and feeds. Mr Lubin has served as the Director of the Saint Lucia Bureau of Standards for a number of years.

Rose Musoke is a designer by profession, but ran a successful bakery business in Kampala for eight years, specialising in high quality cookie production. She has worked as a consultant trainer with Midway Centre, holding practical bakery courses for small-scale entrepreneurs and training bakery trainers for the United Nations Industrial Development Organisation.

Dr Peggy Oti-Boateng of the Technology Consultancy Centre of Kwame Nkrumah University of Science and Technology (KNUST), Ghana, is a Senior Research Fellow and a member of the UNESCO Expert Group on Technology and Poverty Reduction. She has over 20 years' experience in research, development and transfer of food technologies for micro-, mini- and large-scale enterprises, with a particular interest in enterprise development for women. She has also developed nutritious and affordable weaning foods for children using locally available foods. She has written several books and journal articles on food processing and storage, nutrition and sustainable bio-energy for rural development.

Patrick Tibasiimwa is an engineer, based in Uganda, who has 20 years' experience in equipment construction with Afro-General Engineers and Contractors. He has diplomas in electrical engineering and business management and administration, and has worked on enterprise development with the UK non-government organisation ApT. He has trained industrial extension officers for the United Nations Industrial Development Organisation and operates a successful milling enterprise.

Dr Rodah Zulu is a food technologist with several years' experience of food enterprise development in Zambia. In addition to research work at the Food Technology Research Unit, National Institute for Scientific and Industrial Research, Lusaka, she has undertaken consultancy work with the Food and Agriculture Organization (FAO) and the private sector. She has published a number of books and articles on the food resources of Zambia, and is currently working on the fortification of maize meal with large- and small-scale milling enterprises.

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Contents

How to use this book

This book is intended to be a practical guide to help improve the operation of a small flour mill or bakery – with each different aspect covered in separate chapters. It is intended to be read alongside the first publication in this series: *Setting up and running a small food business*, which gives further information on wider aspects of food processing.

Whether you want to start a new business or simply want to achieve an improvement in your existing operations, we suggest that you read both books and make notes on what you need to do in the space provided at the end of each chapter in the **READERS' NOTES**.

However, operating a small business is a full-time job and you may not have the time at the moment to read the whole book. If an area of your operation is posing a particular problem, we recommend that you first read the relevant chapters in both books and act on the recommendations. There are a number of ways in which you can use this book to help you grasp the main points in each subject area.

First, you can look at the **TIPS FOR SUCCESS** at the start of each chapter. These provide ideas for improving a particular aspect of your business.

Next, important points and ideas are highlighted in the text using a bar symbol.

There is a **SUMMARY** of the most important aspects at the end of each chapter.

CASE STUDIES can be found throughout the book, providing real-life examples of how small-scale millers and bakers have overcome various problems they have met in their day-to-day operations.

Finally, at the end of each chapter there is an **ENTREPRENEUR'S CHECKLIST** that you can use to tick the main actions you need to take to improve that aspect of your business.

Introduction 1

The purpose of this book is to describe the activities needed to run a successful small-scale enterprise based on processing cereal grains. This can be either:

- primary processing to convert the grain to flour, or
- secondary processing to convert the flour into a range of more attractive foods such as bread, cakes, biscuits or pizzas.

Cereals provide the main staple food for millions of people, not only in African, Caribbean and Pacific (ACP) countries, but also all around the world. Cereals have been processed for thousands of years using traditional technologies – not to preserve them, because cereal grains have a long shelf life when properly dried, but to alter their eating qualities (flavour, colour and texture) and add variety to people's diets. When cereals are ground to flours, they can be processed in a variety of ways and combined with hundreds of other ingredients. A vast range of baked cereal products has therefore evolved, each with a characteristic flavour and texture to suit local tastes.

Cereal processing and baking provide a major source of income for millions of people. In recent years, new, non-traditional cereal products have entered the markets of ACP countries in response to the changing demands of more affluent urban populations and visitors. Leavened bread is now widely eaten as a staple, often replacing traditional porridges and gruels or flat breads. Bakery products such as cakes and pastries, and fast foods such as pizzas, pies and fried cereal products (e.g. *samosas* and doughnuts) also have growing markets in urban centres. Each of these products is considerably more profitable than traditional fare. The range of flours produced by millers is much less diverse than bakery products, but small-scale millers are able to increase their profitability by attracting retail customers with packaged flour, or diversifying into different flours or specialist combinations of cereal and bean (legume) flours (e.g. for weaning foods).

Cereal processing therefore offers very good opportunities for small- and medium-scale enterprises. The technology is accessible and affordable, the demand for products is high and the level of skill and experience needed to produce high quality products is lower than for many other types of food processing.

This book covers the important aspects of running a flour mill or bakery, including choosing products, preparing a feasibility study, finding and developing suitable markets, selecting equipment, choosing a site and setting up the premises. Developing new products, processing and quality assurance, and managing the finance and business operations are also described. The case studies provide practical examples showing how others have built a successful business.

The fictional conversation given opposite shows the kind of answers that a new entrepreneur might give, and indicates where they can find the information they need. Such an entrepreneur would, hopefully, be better informed once they have read this book. The generic aspects of food processing are described in the companion publication: *Setting up and running a small food business* (Volume 1 in this series) which should be read alongside this book.

Small business adviser	Potential entrepreneur	Aspect to consider	See chapter
Why do you want to start a bakery business?	Because I think people really like biscuits	Market	2
Who else sells biscuits?	My friend Beatrice	Competition	2
Where will you set up your business?	At home in the kitchen	Premises	3
What equipment will you need?	Same as Beatrice uses	Equipment	3
Will it be clean?	I'll get my own special table for biscuits	Hygiene	3
Are the water and electricity supplies OK?	Sometimes	Services	3
Have you thought about making a different product?	No	Product development	4
Will the quality be OK?	Well I hope so	Quality	5
How many will you produce?`	Maybe as many as I can sell	Quantity	6
Will you employ others?	It all depends on how much money I can make	Production	6
Have you done this before?	No, but I watched Beatrice	Experience	6
Have you been trained at all?	I told you, I watched Beatrice	Expertise	6
How much will the biscuits cost?	I haven't a clue	Price	7
Where will you get the capital?	What's that?	Finance	7

Markets for flours and bakery products 2

2.1 Feasibility, customers, competitors and marketing

The need for a feasibility study

The first step towards operating a successful new business is to have a good idea, but this alone is not enough. You also need to find out whether the idea is feasible, and if necessary to convince financial backers (friends, family members, banks or shareholders) to support the idea. A feasibility study is used to find out about the different components of the proposed business. When this information is written down, it is known as a business plan (Table 2.1).

It is not always easy to get started, but with persistence, help and determination, almost anyone can start a small bakery or milling business. Don't let another person's success be the criterion for you to go into business. Case studies 2.1 and 2.2 illustrate the value of perseverance and the need to conduct a thorough market and feasibility study.

Tips for success

Getting started:

- ✔ Before setting up, get some basic knowledge and be ready to have additional training if you need it
- ✔ Do a proper feasibility study; don't take any short-cuts
- ✔ Be dedicated and believe in what you are doing

Customer care:

- ✔ Ask yourself: why should someone buy your product and not another?
- ✔ Keep a close watch on sales and be in regular contact with your key customers
- ✔ Always ask yourself: does my product meet a need? Do I need to improve?

Marketing:

- ✔ Understand the market you are working in
- ✔ Be flexible and change your ideas if you have to
- ✔ Negotiate acceptable terms at the start of the relationship and be firm with the retailers
- ✔ **Finally:** Read sections 3.1, 3.3, 4.1–4.3, 4.7 and 9.1–9.4 in Volume 1: *Setting up and running a small food business.*

Component	Examples of aspects to include
Background to the business	Name, address and contact numbers of business owner, type of product(s) proposed. Any relevant experience of the owner.
Market analysis	Overview of the type(s) of market for the flour or bakery products, estimated present and potential demand, market segments to target, competitors, proposed market share. The main assumptions that have been made.
Site, factory layout and services	Location of proposed mill or bakery and conditions at the site. Building plans and construction work required, construction timetable. Description of plant layout and service requirements (power, water, fuel etc.). Any environmental impacts (waste production, air/water pollution, noise etc.).
Plant and equipment	Proposed production capacity, sources and costs of equipment, production inputs (raw materials, ingredients, packaging), other equipment (e.g. vehicles, office equipment). Machinery commissioning plan and timetable.
Staff	Production and administration staff (number of people and skills required) and training to be given. Staff recruitment plan/timetable.
Production plan, marketing plan	Production rates to meet identified demand, advertising and promotion to be done, distribution methods, sales outlets, projected increase in demand.
Financial plan	Cost of site, equipment and buildings, working capital, (total investment cost), total production costs, sources of finance, cash-flow analysis, balance sheet, profitability calculations (rates of return, break-even analysis, sensitivity analysis).

Table 2.1 Main components of a business plan

Case study 2.1 Getting started in bakery

The manager of a Ugandan bakery making bread, scones, cakes, cookies and samosas attended a short course and used this knowledge to write a simple business plan. 'I was hoping to get a bank loan but I was turned down twice for very unclear reasons. My plan was then shelved for eight months. I used this time to do some short bakery courses.' She had a job in government until she was made redundant in 1995. It took her almost two years from coming up with the business idea to actually starting production. The business was financed partly by the redundancy package and partly by a loan from a friend in return for some shares. 'I had no business background prior to this venture, but I was able to start because I believed in myself and in my dream. I did the studies and I was sure I could succeed. This is what I'd always wanted to do and nothing was going to stop me.'

Another bakery owner advises: 'Do not despise the days of humble beginnings.' He trained and worked as a mechanic for 15 years, during which time he made various spare parts that were not available in the shops. This gave him the idea of building a cheap charcoal oven, and with accumulated savings and a short-term loan, he started on his first home-made oven. His brother, who has a catering background, encouraged him to take it further and start baking small cakes for sale. He was not yet ready to give up his job, but his brother's idea sounded good so he tried it out. 'I was discouraged at first as the cakes got burnt, but then I learned and was able to make some money in the fourth week of production.' He has never looked back.

Mrs L. makes cookies, cakes, meat pies, samosas and pizzas. 'When I was a student in Kenya, I went for lunch at a very nice bakery, so I thought if I ever made enough money I would do it as a side business,' she says. 'I was employed but when my boss was suddenly recalled back home, I had to decide very quickly what was going to become of me. I got a good leaving package, which was enough to buy the basic equipment to start a small bakery.' She had the business idea so approached prospective customers to find out their needs, the types of products they wanted and how regularly they would buy. She also visited suppliers, both for raw materials and for packaging. When she was satisfied that everything could be got locally, she asked a friend to write a simple business plan, for which she paid him. It was about eight months between coming up with the original business idea and actually starting: 'I wanted to be sure that this was right and that it was going to work.' The business was financed partly by herself and partly by a loan from a Women's Finance Trust. She started in 1999 and now has eight full-time workers. The business is a sole ownership but she has just sold some shares to three people.

Case study 2.2 Feasibility studies and market research

A husband and wife in Kampala advise doing a feasibility study before starting a bakery business: 'It is very important to do this before you go into business, and even if you make the mistake of starting without doing one, you can still do it later. It gives you an insight into the reality of the market and the competition, and shows you what to expect. If you see someone running a successful bakery it is very tempting to plunge into the same thing without doing any research, but this is very dangerous. A feasibility study is a must for any serious enterprise. You need to know if the size of the market is worth the investment. You need to know your potential customers and to find out what they need from the product, as well as to identify the quantities they can buy. This is what we were aiming for when we did the studies.' Their thorough preparation has made them very successful, and they now have a market share of 40% for bread, and slightly lower for cakes, in their local area.

Another baker did not do a feasibility study before he started the business, because 'things were done in reverse'. He has now completed his study, which included a market survey. The study suggested that he could do better by introducing other products. As a result he is working on improvements to his packaging, and taking part in trade fairs organised by Uganda Manufacturers Association to better promote his products and the company.

Overview of customer care concepts

The main concept of customer care is that every miller or baker should recognise that their customers [1] are the most important people in their business. A business will only survive if its customers are satisfied with the product and the service. To achieve this, business owners must develop attitudes, ways of thinking and actions that reflect the importance of their customers and they must focus on satisfying them.

[1] A customer is the person who buys a food and a consumer is the person who eats it – these are not always the same people. Customers can be wholesalers or retailers as well as consumers.

For example:

- talk to customers and find out what they like and dislike about each product
- develop customer-orientated attitudes so the customer feels valued when the miller or baker deals with them
- make sure that all actions taken by staff reinforce the idea that 'the customer comes first'.

Case studies 2.3 and 2.4 give examples of different approaches to customer care.

Case study 2.3 Customer care – milling

A maize miller in Uganda has 11 full-time workers. The main customers are up-country towns, supermarkets, shops, schools and institutions. He also sells directly from the factory to individual consumers. He knows that his customers are satisfied with the product: 'I am informed by shopkeepers that my product always runs out first. Customers appreciate the way the product is packaged because it's convenient and the chances of contamination are almost non-existent. I am always communicating with my customers and always prepared to supply them at short notice.
I replenish stocks in supermarkets regularly and supervise this myself. This has given me an advantage over my competitors and, indeed, increased my sales. Our products have now become household names.'

Case study 2.4 Customer care – baking

'I don't want to call them problems but challenges,' says an African baker. He found that customers sometimes raised issues with the sales staff, but they were not reported back to the management. He has now introduced a suggestion box and questionnaires so customers can tell him where improvements can be made. 'I think it's important to respond to queries and concerns as soon as they are raised. We visit retailers once a month and check on our products and the way they are displayed; we also compare them with others on the shelves.' He also offers a small commission to people who bring in new customers.

A second baker noted that her customer complaints were normally to do with bread not being fresh. It transpired that the retailers were not telling their customers when it was two days old. 'We have now agreed with our most valued customers that we will take back unsold bread and exchange it for fresh – as long as it is returned within 24 hours,' she says. 'We do this because we want fresh bread on the shelves to keep a good reputation with customers. We are able to sell the returned bread at a slightly lower price direct from the factory to customers who know it is not as fresh as they can buy in the shops.'

A third baker commented: 'I have encouraged feedback from customers and I have tried hard to give them the products they want. This means providing a product, even if the demand is not so high, because one satisfied customer always means a few new ones. With every supply we make, the retailer gets an extra dozen to cover any losses they might incur from items remaining unsold.'

Competitors

Many small-scale millers and bakers who were interviewed for this book complained about the activities of their competitors. For example, they considered that some competitors use underhand practices to win customers, make false allegations or make substandard products to increase their profits (see Case studies 2.5 and 2.6). It is difficult in a book of this type to describe in detail the ways in which small businesses can compete effectively and honestly but, in summary, the following actions can assist a genuine small-scale baker or miller:

- develop good relationships with customers, treat them with respect and deal with them honestly
- deliver what is promised and on time
- do not make false claims in promotional materials
- do not spread rumours about competitors

- find out from consumers and trade associations what competitors are doing and saying
- identify competitors' strengths and weaknesses
- use the information to be 'one step ahead'.

It is also necessary to take competitors' activities into account when deciding the price that will be charged for a product. Further details of product costing are given in Volume 1: *Setting up and running a small food business*, and in Chapter 7.

Case study 2.5 Bakery competitors

The main competitors for Mr and Mrs L. are small bakeries that are not registered 'so they get away with a lot,' said Mrs L. 'Some concentrate on buns as opposed to loaves, and others make cakes, but only small cup-cakes with basic ingredients and the prices are quite low. Some of these products taste really flat but the low prices are what attracts customers.'

Another African baker commented: 'Some of my competitors make sub-standard goods, but they have been in the business longer and know all the tricks. Some have actually tried to copy my products and the way I pack and label them, which has somehow affected my sales. Consumers think that the products are from the same person who is trying to use tricks to make more money. I have overcome this by increasing my packaging budget and packaging my products more attractively, and this has worked for me.'

'Supermarkets and groceries around the city are flooded with all kinds of goods in my product category, which means that I have had to be very innovative,' says Mrs E. 'I have tried to find out as much as possible about my competitors and their production routines, their delivery schedules and times so that I plan my deliveries to beat all of theirs. I have personally carried out surveys and asked customers what makes them buy one product and not the other. I have then gone back and tried to make the things that people want. At the start I did a bit of research and I found that my products were being over-priced by retailers wanting to make large profits, so people were not buying them. I then approached the retailers and we agreed on proper prices for each item.'

Case study 2.6 Flour mill competitors

'Most of my competitors compromise on quality; a few have money but no business sense, and so they use some unconventional methods to win customers,' said one miller. 'Others are very big and well established, and some actually have their own plantations, and so have access to cheaper raw materials. I have introduced different kinds of packaging for different customers. I have tried to be competitive in all areas of the business, including packaging, trading conditions and terms and delivery, and so far this is working for me. I did a market study and my market share is 70%. I think I am among the top five producers in the whole country.'

Another said: 'There is a lot of bad-mouthing in this business – competitors are always discrediting you, but I believe that actions speak louder than words, and so I just show that we have good products. If there is a fault it is not because I am negligent, it's just bad luck, and I say so to my customers.'

By developing good relationships with customers and 'staying above' any arguments with competitors, a small-scale miller or baker is likely to continue the business and enable it to grow. Customers will ignore false information and may even pass on information about competitors' activities that can benefit the business. Other ways in which the relationship with customers can be strengthened include:

- agreeing contracts with retailers/wholesalers and suppliers
- preparing a product guarantee that is written on the label
- accepting liability for any substandard products.

Details of contracts, product guarantees and product liability are described in Volume 1: *Setting up and running a small food business* (section 4.7).

Developing a marketing and selling strategy

2

Some owners/managers confuse marketing with selling, but the two are very different. Marketing is deciding what to do to meet customers' needs, how a product can be made more competitive, and how to produce the correct 'marketing mix' in a marketing plan. Selling is the process that results in a customer buying a product.

> *So good marketing paves the way for successful selling by making a customer ready to buy a product. Do a proper market survey before venturing out, and use it. Research your choice products: good market information helps you to reduce risks.*

Although most bakeries have a wider range of products than milling businesses, the principles involved in developing a marketing and selling strategy are the same for each. The first thing to consider is the marketing mix.

Marketing mix

Once a miller or baker has identified their main customers, where they live or work and how they buy their food, information on the quality and price that consumers expect is added and a marketing mix produced (Fig. 2.1). The miller or baker can then use this information to refine their products and the way that they are sold to meet the needs of the customers.

This involves:

- creating or modifying a product so that it has the appearance, flavour, size etc. required by the customers
- where necessary, developing an attractive package
- making sure that the places where the product is sold are the ones that the intended customers use
- using methods of promotion that reach the intended customers
- setting a suitable price.

Further details of product development are given in Chapter 4 and pricing is described in Chapter 7.

Product	Place
Better quality and appearance	Longer opening hours
More nutritious	More attractive / cleaner sales outlet
More varieties	Popular location
Different flavours	Delivery service
	Fast and friendly service
Promotion	**Price**
Targeted advertising to specific groups of customers	Lower prices
Free samples	Discounts for larger quantities
Trade fairs, shows and special events	Special offers
Special promotions	Credit facilities for retailers
In-shop displays	

Fig. 2.1 Examples of factors to take into account in a marketing mix

The marketing mix is not a single exercise done when a business starts. It should be regularly updated and reviewed to improve it or even to change it completely. Producers should be aware of feedback from their customers and retailers, they should notice any changes that competitors make to their products, and they should take account of any customer complaints that are received.

The following sections briefly examine each component of the marketing mix for milling businesses and then for bakery businesses.

2.2 Markets for flours

Some small-scale millers, especially in rural areas, think of themselves as part of the agricultural industry with a role in the food production chain that involves turning grain into flour. This attitude focuses on supply rather than demand. More successful millers have a different view: they see themselves as processors who can create products to meet the identified needs of customers. Examples of this approach are described in Case studies 2.8 (page 32) and 4.1 (page 91).

The main types of flour produced by small-scale millers are shown in Table 2.2. Details of their production methods are given in Chapter 4. Although wheat flour is an essential ingredient in most bakery products, its production has not been included in this book because it is rarely produced on a small scale [2] in ACP countries. More usually, wheat is milled in large-scale centralised mills or wheat flour is imported.

Milled products
Cassava flour
Composite flours (soyabean or other legume flour mixed with a cereal flour)
Finger millet flour
Legume flours
Maize flour
Rice flour
Sorghum flour
Weaning food mixtures (cereal and legume flours)

Table 2.2 Types of flour produced by small-scale processors

There are four main types of local markets for flours:

- custom milling [3]
- retail markets
- bulk wholesale
- institutional markets.

There are advantages and limitations to supplying each type of market (Table 2.3). In addition, flour millers can also consider export opportunities to neighbouring countries or regions. However, export marketing is expensive and small-scale millers may be wise to obtain information on markets and negotiate partnerships with foreign investors from international organisations that specialise in this area (Appendix II).

[2] Definitions of small-, medium- and large-scale processing are given in the Glossary.

[3] Also known as 'contract', 'toll' or 'service' milling.

Market type	Typical outlets	Examples of market segments	Advantages	Disadvantages
Custom milling	Sales from the mill.	Local residents who bring their own crop for milling.	No expertise or expenditure needed for marketing, packaging or distribution. No skills required for negotiating with suppliers or retailers.	Production can be intermittent and production levels are often low. Downtime while the miller waits for customers. A fixed number of customers in a limited area make it difficult for the business to expand.
Domestic retail	Supermarkets, shops, open markets (each can be different types including up-market, budget etc.).	Families can be urban wealthy, rural wealthy, urban poor etc.	More profitable than custom milling or wholesale. Good opportunities for business expansion.	High levels of competition, more risky/less secure market than custom or wholesale.
Food processors, food service establishments, wholesalers	Bakers, canteens in large factories or offices, restaurants, takeaways and hotels, wholesale agents.	Professional buyers in these establishments; consumers may be workers or visitors.	Large bulk orders, often using contracts, help guarantee income and business planning. Cheaper bulk packaging and fewer distribution problems.	Lower profitability than retail sales. The loss of a large buyer is more significant.
Institutions	Hospitals, schools, prisons, army barracks.	Professional buyers in the government ministries that run these establishments. Consumers may be staff, patients, children, prisoners etc.	Large bulk orders, often using a fixed term contract, guarantee income and help business planning. Bulk packaging is cheaper than retail packs and fewer distribution problems.	Lower profitability than other sales. The loss of a large contract is more damaging.

Table 2.3 Different markets for flours and their advantages and limitations

Custom milling

This is a popular business in rural areas and in less affluent districts of urban centres, where it provides a service to low-income customers who wish to mill home-produced grains and may not be able to afford packaged flour from retailers. Customers bring their grain to a mill and have it ground in exchange for a small fee or a proportion of the flour. In Case study 2.7, custom milling was used as a starting point for the development of a much larger milling business.

Case study 2.7 Custom milling

After graduating as a food technologist, Ms T. started her Tanzanian grain milling enterprise in 1993, operating it as a custom mill. After three years she changed the business and started packing milled sorghum, millet, blended cereal–legume flours, soyabean flour and cassava flour for distribution to bakers and manufacturers of soya drinks. She has a 60% market share in these categories of customers. There are five other main competitors, but these cause no problems, as the market is growing. Her products are well known all over Tanzania, following a big advertising campaign using the radio and television and regular participation at trade fairs and exhibitions. She has also produced a range of promotional items, including leaflets, playing-cards and T-shirts, to advertise her products.

Retail markets

The retail market for flours is mainly household purchases for home food preparation. In some countries, flour is sold directly from mills into customers' own containers, but the majority of millers pack their flour into 0.5 kg, 1 kg, 3 kg and up to 10 kg retail bags. The bags may be sold from an outlet at the mill or distributed to retail food stores by the miller (see Case study 2.8). Retail markets are highly competitive, and in countries that have opened their economies as part of trade liberalisation measures, there may also be competition from imported flours, because their long shelf life allows them to be easily transported across borders. In some ACP countries, retail packs also 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 the more expensive flour in packets (e.g. guaranteed quality, free from stones or other contaminants, and a guaranteed weight). However, in ACP countries that have government price controls on staples such as maize flour, this can significantly affect the profitability of a mill operation.

Case study 2.8 Milling for retail and wholesale customers

A Ghanaian miller promotes her business through exhibitions at trade fairs, free samples to institutions, public demonstrations of how to prepare products, and occasional free publicity in national newspapers and on Ghana Broadcasting Corporation. She used contacts made by her brother when he lived overseas to supply African supermarkets in Europe and America with maize grits and canned spinach powder for the expatriate Ghanaian community. With the help of her husband, who has a degree in Business Management, she conducted a market study, which showed that she has about 20% of the local market for maize grits. She still has a lot of competition for her products, but her door-to-door sales to customers have proved to be a successful strategy. She has good relationships with her wholesalers and retailers and produces to strict specifications as much as possible. It is sometimes difficult to get prompt payments so she does not over-supply. She only supplies to wholesalers and retailers who have made 50% prior payment and she visits as often as possible to ask for payments to be made.

Wholesalers, food processors, food service industry and institutional markets

Customers in these markets are more likely to be professional buyers who are experienced at negotiating prices and terms and conditions of sale. They tend to buy flour under contract. They are also likely to know in detail what competitors are offering, and it is worthwhile for a miller to conduct research into competitors' service standards and prices before entering into negotiations. In many countries, contracts for supplies to government institutions or international relief agencies are by open tenders that are advertised in the press. Millers should be sure that they have the capacity to meet the volume and quality requirements of orders before accepting such contracts, because defaulting may prove costly.

Wholesale merchants, institutions, international food relief operations and owners of bakeries or other food companies are valuable customers because they buy flour in relatively large amounts. However, the price that they are willing to pay is usually lower than that obtained through retail sales, and even when the higher packaging costs of retail packs are taken into account, the profitability of the retail market is likely to be higher. Small-scale millers may not have the resources to target more than one or two market segments, but to be successful, a company should aim to supply a mix of both retail and wholesale/institutional customers to spread the risk and obtain the benefits of each type of market.

> *In both wholesale and retail markets, successful millers know their customers, what they want and what they dislike, and the strengths and weaknesses of competitors. They constantly strive to improve their products and the service they offer, so gaining advantage over their competitors.*

Markets for other cereal products

Although the focus of this book is on milling, there are related business opportunities in catering that are worthy of mention when considering the markets for cereal products. These may range from newly introduced 'fast-food' outlets in the capital cities of many countries, to traditional prepared foods that are sold through village markets or roadside stalls. Examples of such products are popped and toasted grains (maize, sorghum, millet etc.) and a wide range of traditional staples such as maize doughs (*kenkey*, *ugali* etc.).

The following Case study (2.9) shows how this type of business can be highly successful. Details of kenkey production and other cereal doughs are given in section 4.2.

Case study 2.9 Other flour products

As a teenager, Ms X. lived as a house-help with an aunt in Accra. The aunt cooked fermented maize meal (*banku*) for sale in front of her house. As the aunt did not treat her well, Ms X. left with the little money she had saved. As a means of surviving, she decided to sell fried fish to *banku*-sellers at a busy bus station in central Accra, where travellers needed to eat before embarking on their journeys. She soon found that the fish business was good, and more and more people who bought her fish also asked for *kenkey* (steamed fermented balls of maize meal). So she started producing *kenkey* as well and employed two other women to help her. A few years later, a sister introduced her *kenkey* to a group of friends at the company she worked for. They liked it so much that they recommended it to the company canteen, which then ordered it. Within three years Ms X. was also supplying *kenkey* to doctors, lawyers, schools and other organisations including the Ghana Police Service, Prison Service and Army, who are now her biggest clients. She does not sell her products at bus stations any more, but employs 11 other people to cook and sell *kenkey* and fried fish. She also sells to wholesalers who buy in bulk and sell it to restaurants, traders at bus stations etc.

From her humble beginnings, Ms X. has become one of the top three *kenkey* producers in Accra, and she sets the standard for her competitors. The key for her is quality and so she has employed one person to carry out the daily formulation of the *kenkey* mixture (*aflata*), which ensures that her unique quality product is consistent every day. The only major customer complaint arose when she changed the person who mixed the *aflata*. She quickly took over that part of the process until she could get another employee who had the art of mixing it to the consistency she required.

She uses informal methods to promote her business, for example by giving away free *kenkey* to church organisations, hospitals and children's homes. She was recently given free promotion on national television through a documentary made by the National Board for Small-scale Industry. This resulted in four additional large companies placing orders. One of the secrets of her success is that she endeavours to please all her customers by meeting their needs as much as possible. She does this by selling four different sizes of *kenkey* to meet all pockets, producing *kenkey* with a special pepper and freshly fried fish for young men, and smaller *kenkey* balls to go with soups for school children. In effect she has specific products for each different type of customer.

Elements of the marketing mix for flours

Product

Because flours produced by different millers are superficially similar in their appearance, successful millers must differentiate their product from those of their competitors. They can do this by:

- using attractive packaging
- offering a better service than competitors when supplying customers
- developing new products to create a larger market.

Development of new mixtures of flours and pre-prepared weaning foods are described in more detail in section 4.2. Millers may also be able to increase sales by offering buyers special deals, credit, promotional materials or other incentives that encourage them to promote the flour instead of competitors' products. The costs involved in doing this need to be compared with the increased income to determine whether this type of strategy is worthwhile.

Location (place)

By definition, custom milling is local in its focus and customer base. Many small-scale millers only supply packaged flour to retail shops and marketplaces in their immediate locality and, similarly, most domestic customers only buy flour from local shops or marketplaces. However, because of the long shelf life of flour, millers have the opportunity to use sales outlets that are located long distances away from the mill, especially when supplying wholesale agents or institutional customers.

Promotion

The types of promotion available to millers include:

- newspapers
- radio and television
- signboards, posters, leaflets and cards
- personal contacts
- special promotions.

Different types of promotion may be needed for each market segment. For example, low-income retail consumers are unlikely to have access to television, but may hear a radio or read newspapers. Posters or signboards along main roads and special promotions in retailers' shops are likely to reach more people. The package is one of the most important means of promoting a product in retail markets and an example of attractive packaging is given in Fig. 2.2. In other markets, personal contacts with bakery managers, hotel owners or supermarket managers may be more effective.

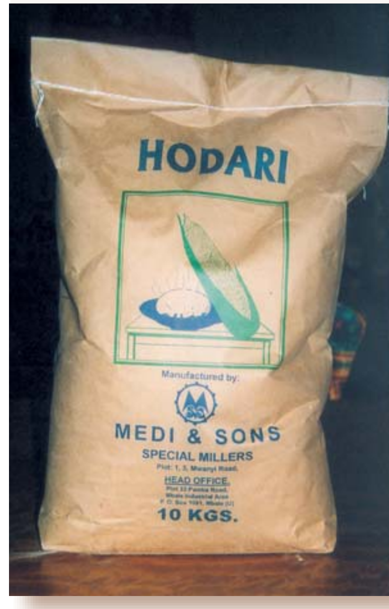


Fig. 2.2 Attractive packaging produced by a small-scale miller (Photo: R. Musoke)

Price

Details of methods used to set the price for a product are given in Volume 1 and Chapter 7. Essentially, the price can be set by adding a profit margin to the total production cost, or it can be based on the prices charged by competitors.

2.3 Markets for bakery products

Bakery products are much more diverse than flours (Table 2.4) and, correspondingly, their markets are also more diverse (Table 2.5). Within each market there are a number of market segments that can be specifically targeted by a baker.

Bakery products	
Bean cakes	Pastries
Biscuits/cookies	Pies
Breads (leavened and unleavened)	Pizzas
Cakes	Samosas
Doughnuts	Scones
Flans	

Table 2.4 Types of products produced by small-scale bakers

It is very important to decide at an early stage in establishing a bakery business the type of market to target and also which particular segments within it.

Market type	Typical outlets	Examples of market segments
Domestic	Supermarkets, shops, open markets, bicycle salesmen, bus/taxi parks, kiosks, street vendors, market traders, straight from the bakery.	Women and children from different types of family (urban wealthy, rural wealthy, urban poor etc.). Workers or business people buying food to eat at the workplace.
Food service establishments	Canteens in large factories or offices, restaurants, coffee/snack bars, kiosks, takeaways, bars, hotels, bus stations, ferry terminals, airports, entertainment venues, sports stadiums etc. (Each can be different types including up-market, budget etc.)	Professional buyers in these establishments, although larger hotels and restaurants may employ in-house bakers. Consumers may be factory or office workers, tourists or other travellers.
Institutional	Hospitals, schools, prisons, army barracks.	In some countries, bakery products are bought by professional buyers in the government ministries that run these establishments, but in others the staff in the institution may have this responsibility. Consumers may be staff, patients, children, prisoners etc.
Wholesale	Wholesale agents	Professional buyers (often only for long shelf-life products, but also for bread in some countries).

Table 2.5 Markets for bakery products

Within each market segment, there are different identifiable groups of customers that can be described by:

- location (e.g. rural, urban, rural town)
- income levels (e.g. wealthy, poor)
- age (e.g. foods that are mostly eaten by children)
- gender (e.g. snacks mostly eaten by men in bars)
- special bakery products for festivals, birthdays, ceremonies or religious occasions
- employment (e.g. foods eaten by office workers at lunchtime, samosas or sandwiches for meetings, conferences etc.)
- nutritional preferences (e.g. diabetic foods, weaning biscuits, gluten-free foods).

Each group may prefer a particular type of product and may also have different requirements for quality, price, packaging etc. Once bakers have decided who their main customers are, they should then devise promotion and sales methods that suit the selected groups. Customers' perceptions are not just about price and quality, but may also include status, enjoyment, attractiveness, convenience, health or nutrition. Bakers should decide which factors are special for their product (known as its 'unique selling point' or USP) and emphasise these in their promotion and advertising (Case study 2.10).

Case study 2.10 Meeting consumer needs

In Ghana, Mrs E. has developed different products for different markets. For example, she produces soyabean milk for vegetarians and children, particularly young children who are lactose intolerant. She produces soya meat for vegans, garlic bread for restaurants, soya milk powder for hospitals and she uses soya flour as a substitute for wheat flour in some recipes. She uses honey instead of sugar for diabetic bread. She is very innovative and has lots of recipes for cakes and bread. Her success in the market has been due to her effective response to customer needs by coming up with new recipes and products. She promotes her business through church fairs, parties and friends, but her customers in the various embassies are her biggest advocates. She has now decided to focus on composite bread and vegan foods, which are in big demand. She tries to use the best combination of product, price, place and promotion to sell her foods.

For example, doughnuts, pizzas, buns, samosas and pies are more likely to be consumed as snacks or lunches by travellers, young people or working people. The USP may be freshness, high quality ingredients, novelty, unique taste etc. They should be promoted using posters or giving away samples at popular takeaways, shops or bus stations where there are large numbers of these customers. This type of market is also likely to be more willing to experiment with new products (Case study 2.11).

Case study 2.11 Pizza market in Ghana

Mrs O. conducted a market survey in Kumasi and found that many people would like to eat fast foods such as pizzas, hamburgers, potato chips, kebabs etc. but there were no restaurants serving this kind of food at the time. So in 1999, she started serving pizzas and kebab dishes in summer huts at the bakery. Her customers include embassies, government and private organisations, professional bodies who require conference lunches and dinners, tourists, expatriates, students, home catering and social events such as funerals and anniversary parties. There is a big market for families who like to take their children out for a special meal, without having to supervise their behaviour in a more formal restaurant atmosphere. When Mrs O. first started the business, she advertised through letters and on the radio. She modified her existing billboard to make it more attractive. She gives free meals to good customers in return for their comments on new recipes, but her best advertisement is the quality of the food, the reasonable prices, and the good service. The business has been so lucrative that her husband has designed and built a pizzeria with brick ovens. These outdoor facilities have been so popular that other prospective hoteliers and restaurant operators from all over the country, and from neighbouring Burkina Faso, have come to take notes.

The market for cakes is broadly divided into two: sales of small cakes and slices of cake eaten as a snack or as a family treat, and celebration cakes for weddings, birthdays, graduation ceremonies or other special occasions. The marketing strategy should differ to reflect the requirements of each group of consumers. For example, small cakes may be bought more often by women and can form part of an attractive display of bakery products in retail outlets, where the USP could be value for money or an attractive flavour. Celebration cakes are usually specially commissioned by the customer and the USP here may be the high quality icing or decoration, high quality ingredients or a unique design (see also section 4.3). Promotion of celebration cakes could include delivering leaflets or cards to individual homes, university notice-boards or places such as government ministries, large companies and embassies where wealthy people work. Personal recommendations are often a main source of business for celebration cake makers.

Components of a marketing mix for bakers

Product

Although some of the small-scale bakers interviewed for this book said that they focused on selling a limited range of bread, most successful businesses realised that this is unlikely to be very profitable because:

- they are in competition with larger bakeries that have greater economies of scale and can sell bread more cheaply
- there are likely to be many other small bakers in competition, making similar bread. This results in bakers having to reduce either the size of individual loaves (which is illegal in some countries), or the quality of their products by buying cheaper flour or other ingredients.

In either case, a limited range of breads makes a profitable operation difficult to achieve.

> *A more successful approach is to diversify production to include a range of cakes, tarts, pies and pastries, as well as bread and buns. Although this is more complex and requires careful planning, it means that a baker is not 'putting all his/her eggs into one basket'.*

If sales of a particular product are low one day, it is likely that sales of another product will be higher, and overall the level of profitability is maintained. In addition, the profit margins on speciality pastries and pies are higher than for bread (see Case study 2.12).

Other advantages of producing a range of products are:

- the bakery is likely to attract a wide range of customers. A person may come to buy a particular type of product, perhaps a pie, but will also be attracted by something different (maybe a flan or a pastry) as well
- the baker gains a reputation for innovation and attracts customers who are looking for something different
- if the quality of products is consistently high, customers will recommend the baker to friends and place special orders (e.g. for birthday or wedding cakes, snacks for parties etc.)

- a retail display that contains a wide variety of baked products is attractive to customers, offering them a greater choice. It also demonstrates the skill and professionalism of the baker. The customer then gains greater confidence in the quality of the products.

Case study 2.12 Developing a range of bakery products

Bakery owners in Kampala, Uganda developed a 1 kg loaf for big institutions and hotels and introduced salted bread on a small scale. Both products are selling well so the bakers are considering increasing production. They have also introduced a new loaf – which is really the usual white loaf but has food colour added to enhance its appearance. This loaf sells very well because people think it is made by a large bakery. Since launching these new products, the bakery's sales have increased significantly. The bakers asked their existing and potential retail customers about the taste of their bread and cakes, the way they are packed and distributed, and the terms of payment. 'These people were able to give us some very good tips and we implemented some of them which has really helped the business,' they reported.

Mr L. makes all kinds of baked cereal products, but the main ones are cakes, pizzas, flans, meat pies and sponge rolls. He sells them to hotels, supermarkets, grocers, restaurants, schools and institutions. The business is developing at a manageable pace and he is hoping to move from rented rooms into his own premises soon. He advertises his products using posters placed strategically in the city and richer suburbs, and he also distributes small business leaflets and cards in different shops. He describes his main strengths as consistent quality, creating new products for different markets, and improving existing ones to suit different tastes. 'I always ensure a unique product and introduce new items by diligently studying my competitors' products and devoting myself to make something different. I have been very successful at this. My competitors have better premises, facilities and staffing, but I have always challenged them on new or improved products and it is working out well.'

However, producing a wide range of products will only be successful if the market contains sufficient customers with enough money to buy these products and who are willing to try something new. In practice, this means that in most ACP countries, such a bakery should be located in an urban centre to attract business people, senior government or diplomatic staff, or it should be close to tourist venues. Bakers that have selected richer customers as their main market have located their production and/or retail facilities in such areas. Examples include new high class shopping malls, sports facilities and places of entertainment, or close to more affluent residential areas. One successful baker obtained the majority of her business by selling speciality breads and pastries directly to staff in foreign diplomatic missions. The principle can also be applied in a more limited way by peri-urban or rural bakeries, where a selection of cakes can be offered alongside the bread.

In order to produce a wider product range, a baker should have:
- sources of recipes and ideas for new products
- technical knowledge and skills to produce different products to a consistently high quality
- facilities and equipment to produce the products
- a careful market analysis to ensure that each type of product meets consumers' needs
- careful production planning to ensure that all ingredients are available when required and that changeovers between different products take place without loss of productivity
- detailed product costing for each type of product
- detailed analysis of sales data to identify which products are more popular and more profitable.

Details of recipes and processing methods for bakery products are given in Chapter 4, production planning is described in Chapter 6 and costing in Chapter 7.

Location (place)

In contrast to some other types of food processing, the majority of small-scale bakers have local markets for their products. Most customers only buy baked products from shops and marketplaces in their immediate locality. In some urban areas, all the customers for a small bakery live within a radius of 1 km or less from the plant. This is particularly important when deciding on the site for a bakery (see section 3.3 and Case study 2.13).

Case study 2.13 Importance of location

Kabalagala is a fast-growing neighbourhood on the edge of Kampala, Uganda and Mr B.'s bakery is located here, between a dry-cleaning business and a supermarket. It is small and would not catch your eye until you enter and see the fine display of bread, cakes and other products. Mr B. has been in operation for four years and sees his main business strength as his location in a busy, elitist neighbourhood where consumption of bakery products is high. He has a large volume of sales directly from the premises, selling everything that he makes each day, and there is good potential for further expansion. He also sells to other local retailers. The location was selected because the family already lived there and knew the neighbourhood, the local chiefs and all the important contacts well, 'so we just knew that it was the right place for us'.

After 30 years' work as a banker, Mr S. was considering retiring. He decided that a bakery was the type of business investment that would give him a good return and create an income for the family. He carried out a feasibility study before establishing the business and then invested his retirement benefits together with a loan from the Development Bank of Zambia. His study found that the part of Lusaka where he was considering locating was growing, but it had no bakery. He felt that even if several bakeries started, he would still remain in business due to the high population growth in the area and the establishment of other businesses whose workers he could supply. After five years, Mr S. considers that he has a small market share because of many competitors, but he is still able to achieve the level of income he requires.

The decision on where to locate a bakery depends largely on the target customers. For example, a baker whose main market is low-cost bread or buns, eaten for lunch or as snacks, should select a location in a city centre to supply office workers, or near to industrial areas to supply workers from the factories. Many urban centres in ACP countries are expanding rapidly with new residential areas growing up around the edges or at 'trading centres' or 'growth points'. These new areas initially have few retail outlets and facilities, and are therefore an ideal location to start a new venture.

Promotion

Most bakery products are not packaged and there is therefore no label to promote the brand or the company. Different types of promotion are available to bakers, including newspapers, radio, leaflets and cards. They can also use personal contacts, give away free samples in retailers' shops, and provide special promotions or stalls at trade fairs, entertainment or sporting venues and other gatherings (Case study 2.14). Low cost promotional methods can include posters or signboards along main roads to attract the attention of travellers or tourists. Personal contacts with restaurant and hotel managers may also be productive.

> *Be on the lookout for trade shows, fetes, open days and other big gatherings. Some bring more money in a day than you would otherwise make in weeks. Give to a charity whenever you can: it pays.*

Case study 2.14 Promotion and advertising

One innovative baker attends all the social gatherings he can. 'I send scouts to find out what events are happening and then make sure I have leaflets or samples of my products ready, so that people can get to know me. At the moment I can't afford to advertise on big media like TV and radio, and I don't know if it would really improve my sales, but if a good offer comes up, I might try it after my planned expansion.'

Another reported that they had advertised once but gave up the idea because it did not work, and sales did not go up. 'But it was not totally wasted as more people got to know us. We have not given up the idea completely and are looking at other options. I know that advertising works but it has to be targeted to a specific market otherwise you sink money into it and don't get any benefit.'

Summary of the chapter

✔ A feasibility study is essential to help you plan the business properly

✔ Plan well: this is very important. Put in as much time as is needed

✔ Always put the customer first and develop work practices that focus on meeting customers' needs

✔ Aim to please: customer satisfaction is very important for the growth of the business

✔ Listen to your customers and consumers. Be honest with your customers; do not take advantage of their ignorance

✔ Consider all four types of market for flour and bakery products (domestic, food service industry, institutions and wholesalers)

✔ It is important that your products, methods and places of selling, prices and types of promotion match your intended customers

✔ Always take account of competitors, but do not let them distract you from your own business aims

✔ Decide what makes your product different from those of your competitors and emphasise the benefits in your promotional efforts

✔ Prepare a marketing plan to guide the development of your business

✔ Choose your retailer or distributor carefully and check to make sure they are doing their job properly

✔ Keep in regular contact with consumers and make sure they are satisfied with your products

✔ Subscribe to industry associations and magazines

Entrepreneur's checklist

❑ Have you done a feasibility study?

❑ What changes can you make to your business to improve customer care?

❑ Do you know precisely what types of customer you are targeting?

❑ Does your product meet their needs? If not, what do you need to change?

❑ Do you sell your products at places where your intended customers will find them?

❑ Are your prices competitive?

❑ How can you improve your promotion and reach more customers?

❑ Do you know who your competitors are and what they are doing with their businesses?

Readers' notes

Please use this space to make your own notes on Chapter 2.

Setting up production 3

3.1 Getting started

Selecting the location

Although clean water and drainage are needed in mills and bakeries (for conditioning grain, preparing dough, cleaning machinery etc.), the volume required is much less than in other types of food processing. Because there are no large volumes of liquid waste to dispose of, there is greater flexibility in the choice of a factory site. It is therefore feasible and desirable to locate a bakery close to customers, provided smoke from fuel-fired ovens does not cause a nuisance to neighbours. The best location for a mill is determined by the following factors:

- proximity to sufficient numbers of customers
- proximity to the source of raw materials
- availability of services (especially electricity)
- proximity of a suitable site for disposal of solid wastes
- the need to avoid noise and dust from the mill becoming a nuisance to near neighbours.

Tips for success

Millers:

✔ Choose a building with enough space for workers to move around easily

✔ Seek advice on the best sources of equipment, packaging and ingredients

✔ Seal up any cracks in walls and floors and ensure all windows and doors are insect-proof

✔ Reduce flour losses in ducts, at the cyclone and by mishandling at bagging stage – it is not only a loss to the business but also an environmental hazard

✔ Use the lowest horsepower motor that is sufficient for the size of the mill

✔ Train operators to use equipment safely

Bakers:

✔ Be innovative and experiment with new products and ideas

✔ Have a diversified product range to make meaningful returns

✔ Try as much as possible to use local raw materials

✔ Choose a site that is close to your customers

✔ Seek advice to help you invest your money in the correct equipment and get value for money, both before starting up and when replacing equipment

✔ Ensure that equipment is safe to use

✔ **Finally:** Read sections 5.1–5.4 in Volume 1: *Setting up and running a small food business.*

In each of the case studies where flour or bakery products are sold directly from the factory, close proximity to busy roads or a location in a more affluent area are the main factors in selecting a site (see Chapter 2 and Case study 3.1).

Case study 3.1 Getting started

Ms E. wanted a place for her flour mill in a busy, but relatively cheap, neighbourhood with road access and cheap transport. She also hoped to find a place where there were not so many people doing the same thing. 'This place I have now doesn't meet all the requirements, but I didn't have to spend much to set it up. The building is rented and I designed the layout and facilities, importing most of the equipment from Kenya and the UK. The factory is quite big and open, so the machines are well spaced. The processing room is not used for storage so there are no rodents. We have also installed window nets in the storerooms to keep out the rodents, which otherwise invade the finished products. We have a licence issued by the City Council so the site is registered for food production.'

Mr and Mrs B. set out certain conditions for the location of their bakery in their feasibility study. They wanted premises that would be well supplied with utilities and local council services, although not necessarily in or near the city. 'We also wanted a place that could be expanded if the need arose, and a place that gave us the flexibility to build or renovate without causing any inconvenience. And we wanted to be near a main road, preferably a tarmac road where there are plenty of customers. So we bought some land that was suitable and started construction.'

In some countries, industrial buildings are not permitted in residential areas, and an aspiring miller or baker should check with the Town or City Council before purchasing or renting premises. A further factor to consider is the level of rent or cost of land, which is generally higher in a busy or more affluent area. This cost needs to be balanced against the potentially higher prices and increased sales volumes that are possible in such areas, together with better access to services, spares and supplies.

Design and construction of the building

Of the general requirements of all food processing rooms, the three most important factors to consider in the design of mills and bakeries are:

- preventing dust
- good ventilation
- deterring and controlling insects and rodents.

Dust

It is important to prevent the accumulation of flour dust for a number of reasons:

- it contaminates products
- it attracts insects and rodents, which in turn contaminate products
- it is a health hazard to staff
- it has the potential to cause an explosion.

Dust accumulation is prevented by good housekeeping, and a routine cleaning schedule should be a part of a quality assurance programme (see Chapter 5). It is preferable either to dampen the floor before sweeping or to use a vacuum cleaner instead of a broom (sweeping simply raises the dust and allows it to settle elsewhere). Floors and walls are easier to clean if they do not have cracks, and rooms should have ceiling panels fitted to prevent dust accumulating on rafters and dropping off in lumps into the product. The roof space should have access for cleaning. The building should have no flat surfaces, such as window sills, on which dust can settle. Floor-standing machinery should have legs to allow easy cleaning around it, and the layout of machines should allow sufficient room for operators to clean behind the equipment.

Ventilation

The production of large amounts of airborne dust in a flour mill should be avoided because, apart from the health hazard, it can be ignited by a spark from an electric motor or by static electricity [4] . Fires and explosions caused by flour dust are quite common, especially in large mills, and several buildings are completely destroyed each year, often with loss of life. Electrical cut-off

[4] Static electricity is the build-up of an electrical charge on an insulating material such as nylon clothing or rubber-soled shoes, which can create a spark when the material is earthed.

switches and fire extinguishers should be installed in all mills and bakeries. Dust should not be produced if equipment is properly serviced, and can be prevented by fitting a cyclone separator or bag filter to the mill (see section 3.2). If these measures are not feasible, extractor fans and/or good ventilation can be used to remove dust from the building.

Good ventilation in a bakery is required in areas where ovens are located, and can be achieved where there are high ceilings and screened roof vents, which allow the heat to rise and escape from the building. Alternatively, screened windows can be left open or extractor fans can be installed.

Insects and rodents

Processing rooms and storerooms attract animals and insects because they provide a ready supply of food. A rigorous daily cleaning programme to remove food waste is the first way to deter them. A second line of defence is to store ingredients and raw materials in insect- and rodent-proof containers. Where this is not feasible (such as the storage of bulk flour or grain), the storeroom should be made secure against insects and rodents. Doors and windows should be screened, and the joint between the roof and walls should be properly sealed. All storeroom doors should be kept closed when not in use and, if funds are available, insect electrocutor devices should be fitted (Fig. 3.1).

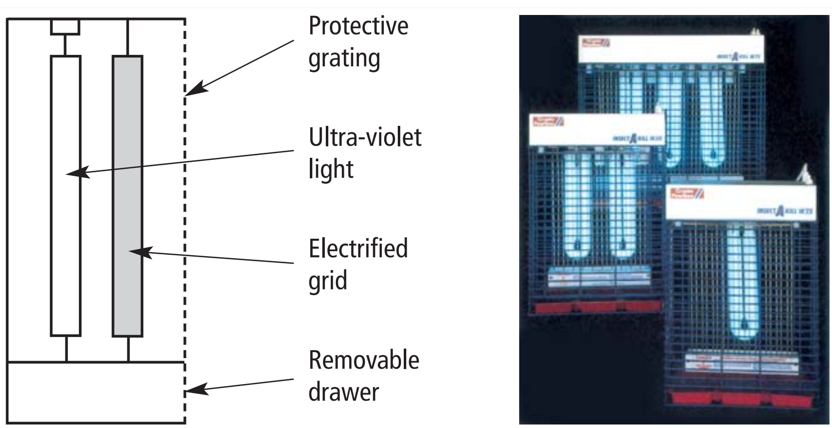


Fig. 3.1 Insect electrocutor (Photo: courtesy of Electrolux Foodservice Ltd)

Despite one mill owner saying 'I prefer cats to rats', the use of resident cats or poison is not recommended for rodent control because of the risk of contaminating products, but traps that contain the rodents are acceptable. Further details and facilities that are required in a mill or bakery, including provision of toilets and hand-washing facilities, are described in Volume 1: *Setting up and running a small food business* (section 5.3).

Electricity

Although it is possible to operate a small mill or bakery without electricity, for example using a diesel-powered mill or a fuel-fired oven, this book focuses on larger scales of operation for which electricity is required. All electric wiring should be of the correct type for the intended purpose and should be installed by a competent electrician, especially where a three-phase (440 volt) supply is used. Electric motors should be fitted with isolators and starters. Power points should be used for one application only and multiple sockets should be avoided, as they risk overloading the circuit and causing a fire. Plugs should be fitted with fuses to suit the power rating of the equipment, and the mains supply should have an earth-leakage trip switch. Care is needed when using fluorescent lights above mills, dehullers and other equipment that has moving or rotating parts, because they can make machinery appear stationary at certain speeds, causing a hazard to operators. Although electric ovens (see section 3.3) are popular in some countries, especially where hydro-electricity is cheaper than fuels, most ACP bakers rely on burning fuels and these are described in detail below.

Selecting equipment

Many small-scale bakers and millers buy the equipment that is immediately available and don't look carefully at the alternatives. This can lead to them selecting an inappropriate machine. To maximise efficiency of production, the capacity of each piece of equipment should be matched to the others. This prevents money being wasted on a machine that is larger than necessary, or creating 'bottlenecks' caused by one piece of equipment that is too small.

> *It is worthwhile to look at a number of existing operations and to research suppliers to find out what is available from further afield before making a decision on what to buy (see Case study 3.2).*

Case study 3.2 Selecting bakery equipment

A Ugandan baker has designed everything himself, with a little help from photos he took at a bakery he visited. The factory is set up in such a way that there is continuous flow of materials, maximising efficiency and safety. Stores for the different stages in the process are placed strategically around the building. 'When we were selecting machines, we invited an expert who helped us to choose simple yet efficient equipment that is widely used in Uganda, and would be easy to service and repair. We visited quite a number of suppliers and tested a lot of equipment. We also had the chance to visit some bakeries and see the machines in operation. The bread ovens were fabricated on the premises and the remaining equipment was all bought locally from suppliers in Kampala.'

In some countries there are import agents in the capital city who can supply equipment, or information can be obtained on overseas suppliers from manufacturers' associations, international development agencies, university food technology departments or trade sections in embassies of other countries.

When ordering imported equipment, it is important to specify the required capacity (in kg, or kg per hour), single or three-phase power supply, the number and types of spares required, and the specific application for which the equipment is to be used. Where possible the model number of a machine should also be given.

3.2 Setting up a mill

Production planning in a flour milling business is relatively straightforward because there are few 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 (hullers, bagging machines etc.) can then be selected to match this capacity (Case study 3.3).

Case study 3.3 Establishing the capacity of a mill

From discussions with retailers, a miller estimates that possible sales of maize flour in a small town are 400 tonnes per week. If the miller expects to have 2% of this market, the production rate = 2% of (400×1000) kg = 8000 kg/week (or 32,000 kg/month).

If production takes place for 5 days per week, milling for 6 hours per day (the remaining time is used for packing), the required throughput of the equipment

$$= \frac{\text{amount of product sold/week (kg)}}{N° \text{ days production/week} \times N° \text{ hours worked/day}} = \frac{8000}{(5 \times 6)} = 267 \text{ kg/hour}$$

So the seed cleaner, huller, mill and bag filler should be selected to have a capacity of approximately 300 kg/hour to meet current demand. If expansion of production is likely, larger equipment could be bought, or the equipment could be duplicated at a later stage.

The expected level of production is also used to decide the size of the mill building. A possible layout for a flour mill is given in Fig. 3.2.

The mill building should include:

- space for weighing incoming grain
- space for grain storage
- space for flour storage
- space for maintenance and repair of equipment
- space for customers (customers should not be allowed into the milling area)
- cupboard with lock for spares and tools
- first aid box
- sand bucket or fire extinguisher (kept in a prominent place)
- hand-washing and toilet facilities, with space to store workers' clothes.

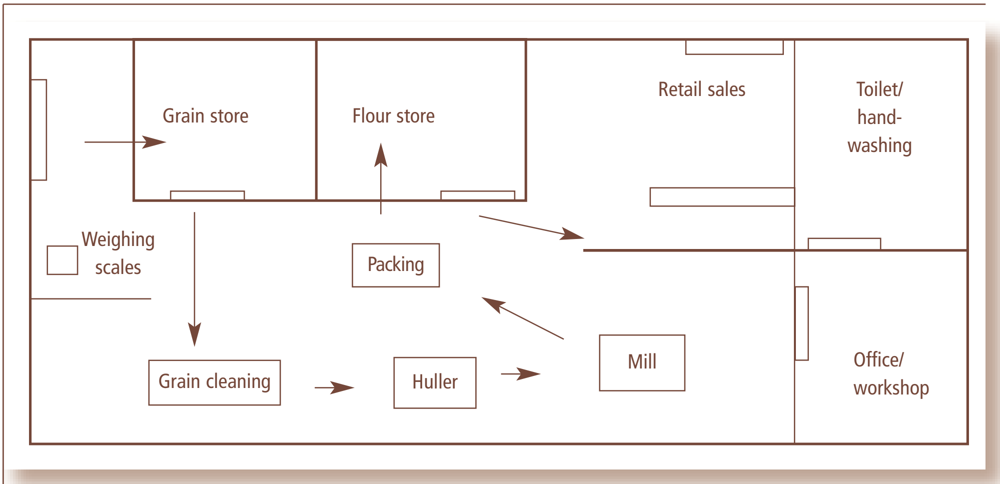


Fig. 3.2 Possible layout of a flour mill

Milling machines require a solid concrete foundation and mills should be securely bolted to the floor using foundation bolts with a minimum length of 45–60 cm. There should be a space around the mill of at least 60 cm for maintenance and cleaning. (Do not allow too much space – it will be used by operators for storage, thereby reducing the amount of space for maintenance.) It is important to have good air circulation to enable the machinery to run at the correct temperature, especially in a mill that uses a diesel engine, to avoid over-heating.

Milling equipment

Design and construction

In ACP countries, milling equipment is usually made from mild steel and is available from any local engineering company that has the necessary welding skills. If the quality is adequate, local suppliers are the best option, especially for mills and hullers, because spare parts and the skills to maintain and repair the machines are readily available. The principles of hygienic design and methods of construction for food processing equipment are described in Volume 1: *Setting up and running a small food business* (section 5.3). Although most flours do not have high levels of risk from food-poisoning micro-organisms, the basic principles of hygienic design should apply to ensure the quality of the end product. The equipment that is required for a small flour mill is shown in

Table 3.1. The main items are a seed cleaner, a huller, a mill and packaging equipment, and these are described in more detail below.

Item of equipment	Use
Main items	
Seed cleaner/inspection table	To remove chaff, dust and other contaminants from grain before milling
Wash trough	To remove stones and other contaminants from grain before milling
Huller or polisher	To remove the seed coat from grains such as maize, sorghum etc.
Mill	To grind grains or dried root crop chips
Heat sealer and/or	To seal plastic bags
Sack stitcher	To seal paper and woven polypropylene sacks
Ancillary equipment	
Conditioner	To adjust the moisture content of the grain before milling
Dryer (usually solar but may be fuel-fired)	To pre-dry grain that is too moist or to dry root crop chips before milling
Destoner	To remove stones from grains before milling
Toasting pan	To roast some types of grains before milling (e.g. production of some cereal/legume weaning foods)
Mixing tank	To prepare pre-mixed ingredients for weaning foods
Screens	To grade flour according to particle size

Table 3.1 Equipment required for grain milling

The design and construction of feed hoppers, hullers, mills and ancillary equipment should ensure the free passage of grains or flour without recesses that could trap food and lead to contamination. Careful design and construction also prevent the release of dust from ill-fitting mill or huller casings, from cyclone separators or associated pipework. The quality of the metal and the construction techniques both determine the risk of machines causing product contamination. Most milling equipment is made from mild steel and it is important that welding is done to a high standard to prevent holes in the weld or small projections that could trap food. All welds should be ground to a smooth finish. Mild steel rusts easily and it is important that equipment is kept dry to prevent rust from contaminating the grain or flour.

> *A good design enables a mill or huller to be easily dismantled for cleaning and maintenance. When this is easy to do, operators are more likely to do it properly without cutting corners.*

Nuts and bolts that are routinely removed for cleaning/maintenance 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 huller, which in turn could injure an operator, and metal fragments from low quality materials can readily contaminate the flour. Case study 3.4 illustrates how the arrangement of equipment can improve efficiency.

Case study 3.4 Layout of equipment

Attendance at a maize milling training course helped this miller to re-arrange his machines and improve efficiency. 'I thought the arrangement of my machines was OK, but during the training I realised that I had problems with the layout, especially with hygiene and flour loss. Since I changed everything around the losses have reduced from 8 kg per 100 kg to less than 1 kg. The efficiency of the machines has also increased from two bags an hour to four bags an hour. We have also made cleaning easier, and now clean every morning and dust the place down every day.'

Seed cleaners for maize

At its simplest, a seed cleaner is a table made from perforated aluminium or steel on which grain can be spread out and examined. Small contaminants such as dust and small stones fall through the holes in the table, while larger leaves, stalks, mouldy grains etc. can be picked out. The procedure can be mechanised using an inclined flat screen that is made to vibrate. Grain is fed onto the screen and the vibration assists in separating out any contaminants. These machines may cause serious dust problems, especially at a larger scale, and more modern machines are fitted with an aspirator to remove dust via a cyclone separator. Seed cleaners should be located in an area of the processing room where dust can be prevented from contaminating other equipment or products. Most small-scale millers do not use a destoner (a gravity separator that will remove small stones), or have provision for separating immature grains, although these are routinely used in larger mills. A destoner (Fig. 3.3) consists of an oscillating inclined screen. Air is blown through the screen with sufficient speed to lift the grain and allow it to fall down the screen under gravity. The air is not fast enough to lift the heavier stones and these are carried upwards on the screen and collected separately.

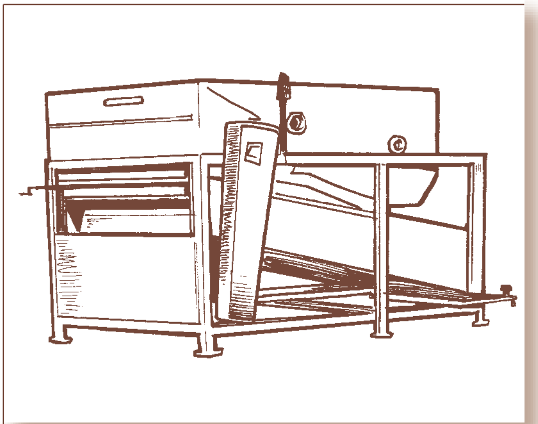


Fig. 3.3 Destoner for maize

Seed cleaners for rice

Paddy cleaners (Fig. 3.4) remove all light contaminants and stones in a single process. If the grain needs washing, this is usually done at a small scale using a trough or tank containing clean water and fitted with a drain tap so the water can be replaced regularly. Iron fragments are removed from the grain using permanent magnets (electro-magnets are not recommended if there is risk of power failure) but other types of metal particles must be removed by hand on the inspection table.

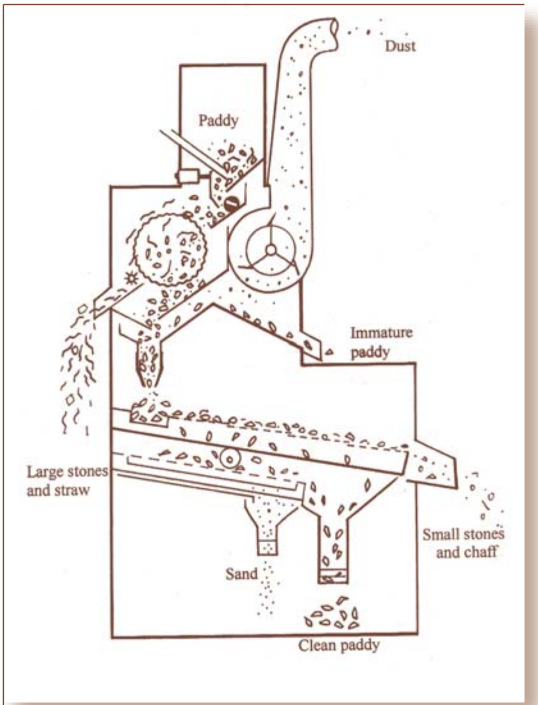


Fig. 3.4 Paddy cleaner

Conditioners

Grains have an optimum moisture content for milling (see Table 5.2 on page 142), and specialised conditioning equipment is available to moisten over-dried grain. However, this equipment is likely to be too expensive for most small-scale millers. A more common problem is that grain is too wet, and many millers have a dryer to reduce the moisture level before milling. This can be a sun-drying area, a simple solar dryer or, less commonly, a fuel-fired dryer. Details of drying equipment are beyond the scope of this book, but sources of information are given in the bibliography. Details of procedures and equipment to measure the moisture content of grains are given in Chapter 5 (section 5.2).

Hullers (or dehullers) and rice polishers

Most cereals require removal of the bran, or hull, as the first step in milling (Fig. 3.5). Different types of machine are used to remove the hulls from maize, rice [5], sorghum etc., but each consists of a casing containing a rotor with or without a fan or motor.
A common design, similar to a plate mill, consists of rotating abrasive discs contained inside a steel casing, which rub the bran from the individual grains.
The feed-rate of the grain is carefully controlled to ensure that it remains in the huller long enough to remove the bran, without excessive loss of the product. A fan separates the bran when the grain emerges from the bottom of the huller.

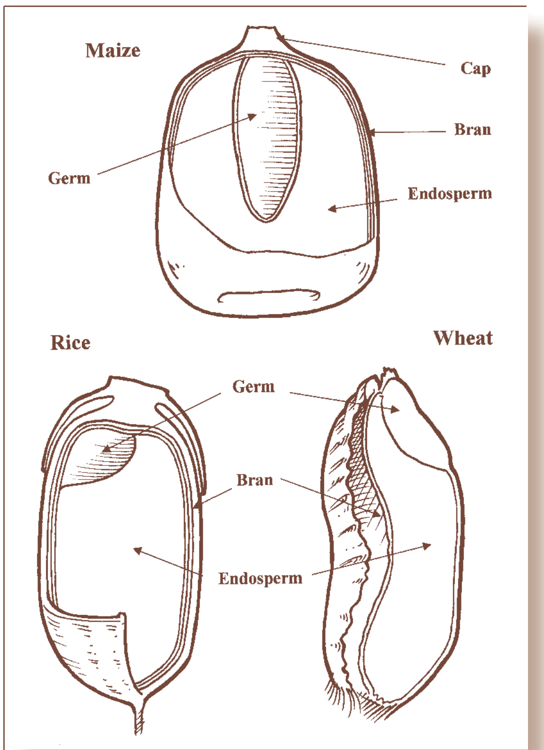


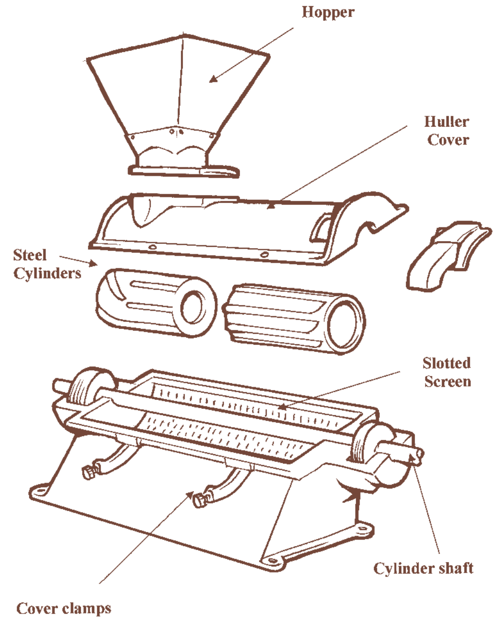
Fig. 3.5 Structures of common cereal grains

[5] Paddy hullers and polishers are sometimes also termed 'mills'.

The Engelberg huller (Fig. 3.6) consists of a horizontal cast-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 on the grain discharge spout controls the pressure on the grain. During operation, the grain enters the chamber and friction caused by ridges on the rotating cylinder removes the hulls. The second part of the cylinder then removes the germ and bran. These by-products, together with broken grains, are discharged through the screen.

The Japanese rubber roller-type huller operates on the principle that if paddy grains are pressed between two resilient surfaces moving at different speeds, the shearing action (or friction) removes the husks (Fig. 3.7).

These machines are made in several forms. A single roller type only removes the hulls to produce brown rice; a second section may be used to 'whiten' brown rice by removing the bran, or these sections may be combined in a single-pass machine. Rubber-roller hullers are gaining in popularity in many regions because they cause less grain breakage, and they are



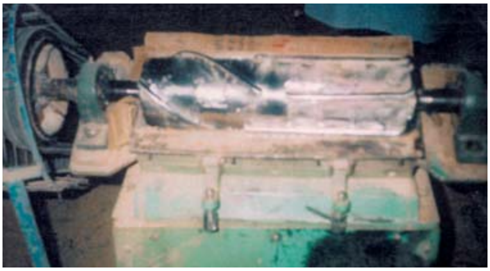


Fig. 3.6 Engelberg type steel roller huller
(Photo: R. Musoke)

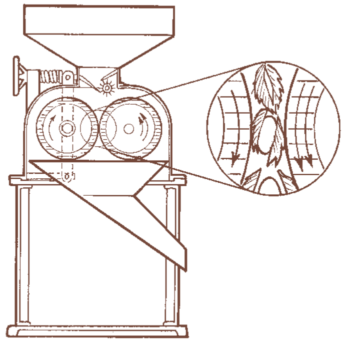


Fig. 3.7 Shearing action on grain

less likely to be damaged by stones in the grain or by unskilled operators. However, single rubber rollers do not 'polish' the rice (remove the bran) whereas the steel rollers of the Engelberg type both remove the husk and polish the rice. Combined hulling and polishing rubber-roller machines are more expensive and complex than Engelberg machines. The Engelberg huller is also more robust and requires less maintenance, lasting for 20–40 years depending on its use.

Mills

Traditional stone mills are used in rural areas of some ACP countries, mostly in homes for domestic production. Motorised stone mills are available in a few countries, but they are not widely used in commercial applications and are not included in this book. The types of mill that are used for commercial grain milling can be grouped into two types: plate mills and hammer mills [6].

Plate or disc mills are found most commonly in West Africa, and consist of grooved cast iron plates contained in a steel casing. There are a large number of designs, but the most common is the single-disc mill. The grain passes through an adjustable gap (or 'nip') between a stationary casing and a grooved disc rotating at high speed, driven by an electric or diesel motor (Fig. 3.8). The grains are split mainly by shearing forces (Appendix I) and this type of mill can be used for wet or dry grains.
A common practice in West Africa is to soak maize grains in water for a few days before milling. This promotes a natural fermentation process and alters the flavour. The level of acidity also increases, extending the shelf life for a few days. In Latin America, maize is sometimes soaked in lime-water (calcium hydroxide solution) to soften and help

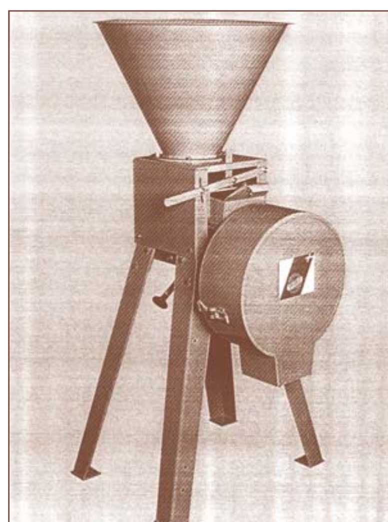


Fig. 3.8 Single-disc mill (Photo: courtesy of Skiold Saeby A/S)

[6] Another type of mill, known as a roller mill, is used to mill wheat. These are large, expensive machines and are not used by small-scale millers.

remove the seed coat. In both cases the maize is then milled in a plate mill or pounded in a pestle and mortar to make products such as tortillas in Latin America and *ugali, banku, kenkey* or *uji* in African countries. Details of these products are given in Chapter 4 (section 4.2).

Double-disc mills, which have two discs that rotate in opposite directions, and pin-and-disc mills, which have intermeshing pins fixed either to a single disc and casing or to double discs, are less commonly used by small-scale millers. Both produce greater shearing forces and more effective milling, but are considerably more expensive than single-plate mills.

Hammer mills consist of a chamber that is lined with 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 (Fig. 3.9). The hammers hit the grain at high speed and throw it against the beater bars. The grain then bounces back into the path of the hammers (if the beater bars were not there, the grain would simply rotate around the mill at the same speed as the hammers). The grains are broken mainly by impact forces (Appendix I). The fineness of the flour is controlled by the size of the holes in the screen. If very fine flour is required, a screen with small holes is used. If a screen with larger holes is used, the hammers still break up a lot of the grain to fine particles, but the larger particles also pass through the screen to produce coarser and darker flour. The size of holes in the screen also affects the output from the mill, which is higher when a screen with larger holes is used compared with a fine screen. These mills cannot be used for wet milling as they readily block with paste.

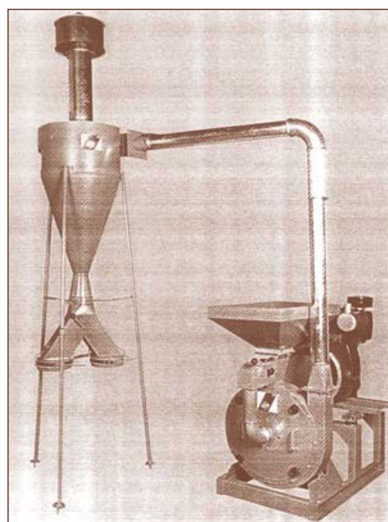


Fig. 3.9 Hammer mill (Photo: courtesy of Skiold Saeby A/S)

Hammer and plate mills can be operated in two modes: either with a free flow of product through the mill in a single pass, or with the outlet from the mill restricted by a screen. The flour remains in the mill until the particles are small enough to pass through the screen. Under these 'choke' conditions, shearing forces play a greater part than impact forces in the milling process.

Cyclone separator

When this is fitted, the flour is sucked through the screen and transported to the cyclone separator by a fan. Most fans have straight blades in a simple fan case, and move the flour upwards; they are not suitable for conveying it horizontally over long distances. When it reaches the cyclone, the flour rotates in a spiral action and the air is separated. The flour then drops into a collecting bag underneath (Fig. 3.10). The air escapes via a vent pipe at the top of the cyclone to the outside of the building. Correct design of the cyclone separator is important to avoid losing flour into the air. The inlet pipe must enter the cyclone tangentially. The outlet (vent) pipe should be three times the area of the inlet pipe, and should be angled to ensure that rain cannot enter it.

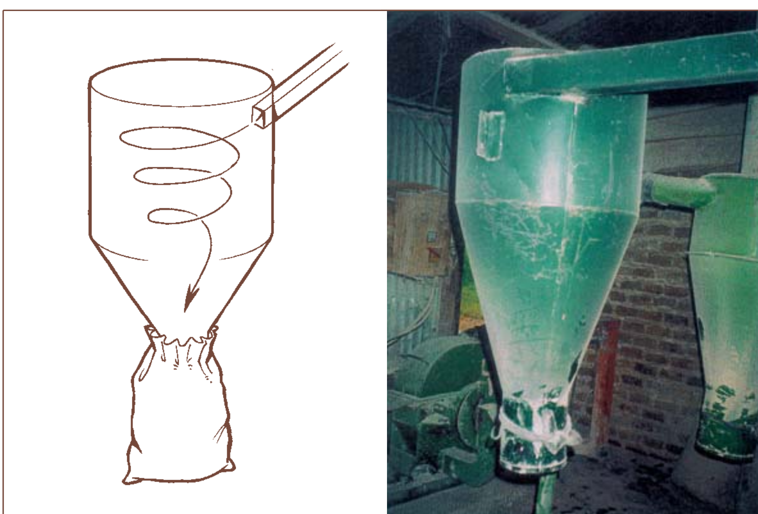


Fig. 3.10 Action of a cyclone separator (Photo: P. Tibasiimwa)

The better the fan suction, the quicker the flour can be removed from the mill. However, many mills have poor suction and the hammers just keep pounding the same flour and wasting energy. The following factors will maximise the amount of suction:

- air intake of the correct diameter (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 periphery of the fan intake)
- smooth corners to ducting and pipes (Fig. 3.11)
- sealed joints to reduce air leakage on the suction side and prevent air blowing out with loss of flour on the pressure side.

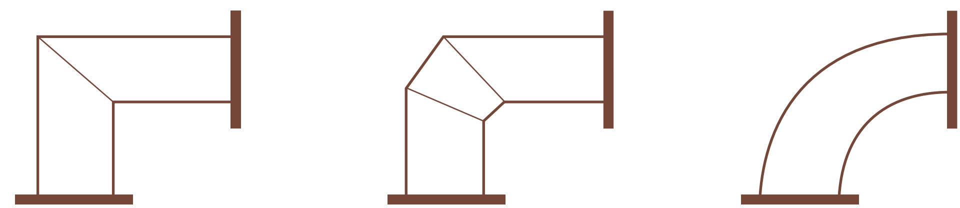


Fig. 3.11 Bend designs in pipework for conveying flour from a mill

Packaging equipment

Flours are packed and sealed in paper or polythene bags for retail sale, or in polypropylene, multi-wall paper or cotton sacks for bulk sales. Most small-scale millers fill bags and sacks by hand and then check the filled weight on scales (Fig. 3.12). It is much faster to use a manual or semi-automatic bagging

Fig. 3.12 Weighing flour (Photo: R. Musoke)

machine. The equipment can be adjusted for different fill weights, and the flour is released from a hopper into a weighing section. The correct weight of flour is then dropped into a bag or sack (Fig. 3.13). Polythene bags are tied or, preferably, heat sealed. Paper bags and all types of sacks can be sealed using an electric sack stitcher (Fig. 3.14).

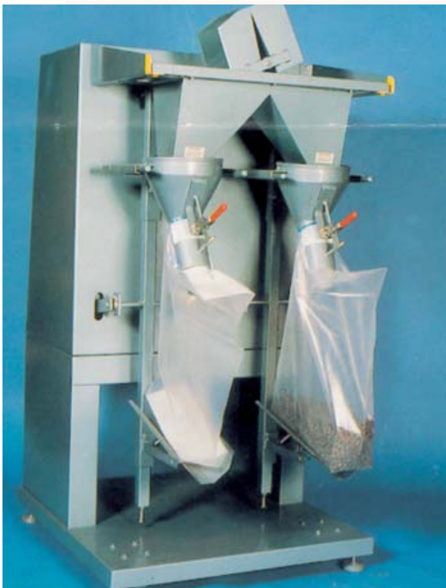


Fig. 3.13 Manual bagging machine for flour (Photo: courtesy of A.T. Sack Fillers-Simplafill Systems Ltd)

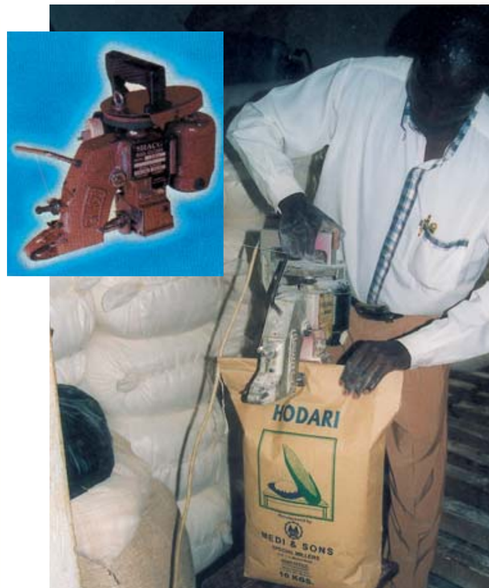


Fig. 3.14 Sack stitcher (courtesy of Shaco Enterprise. Photo: R. Musoke)

Packaging materials

In most ACP countries, local production of paper bags meets the needs of millers, and local printing companies can print brand names and company logos on the bags. Multi-wall paper sacks or woven polypropylene sacks may have to be imported, or cotton or jute sacking material used instead.

3.3 Setting up a bakery

A bakery should have space and facilities similar to those described for a mill, and additional space for:

- preparing and baking the dough
- temporary storage for dough awaiting baking
- cooling the baked products
- testing ingredients and products for quality assurance
- washing equipment.

An example of a layout for a bakery is shown in Fig. 3.15.

The size of a bakery building and the throughput of equipment depend on the expected sales (determined by a market survey). An example showing how to calculate the size of equipment is given in Case study 3.5 and in Volume 1: *Setting up and running a small food business* (section 5.3). Case study 3.6 shows how to calculate the amount of ingredients from a standard recipe.

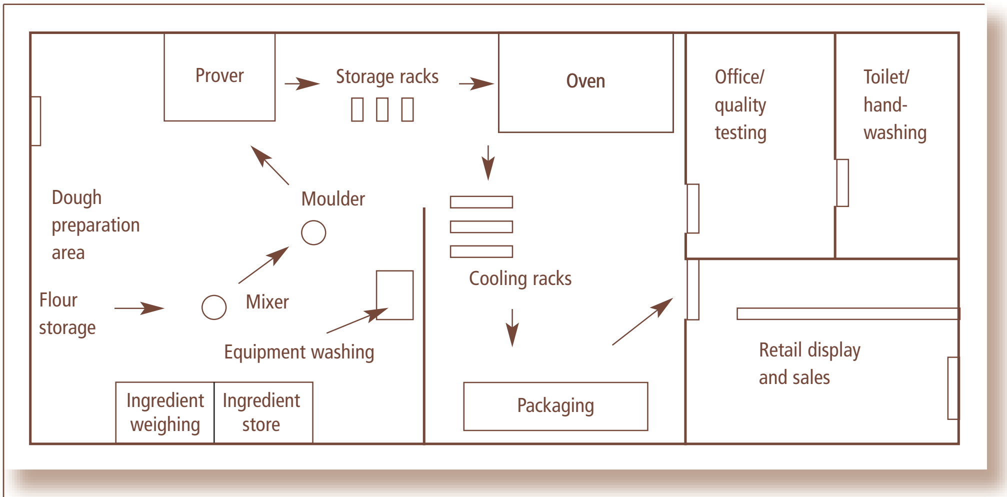


Fig. 3.15 Possible layout of a bakery

Case study 3.5 Calculating the size of bakery equipment

The demand for bread was estimated to be 450 loaves per day (each loaf is 400 g and the total is therefore 180 kg per day). However, the amount of ingredients is greater than the amount of end product due to losses during the process (Table 3.2). With losses of 12% the amount of dough that is made per day = 180 + (180 × 12%) = 201 kg.

Mixing takes place for 3 hours, so the capacity of the mixer = 201/3 = 67 kg per hour.

Each batch of dough is mixed for 15 minutes.
Three batches per hour are therefore possible and the size of the mixer = 67/3 = 22.4 kg (i.e. a bowl size of 25–30 kg).

Baking takes place for 5 hours and each batch of bread needs to be baked for 20 minutes (two batches per hour).

The capacity of the oven = 450/5 = 90 loaves per hour = 90/2 = 45 loaves per batch.

Stages in a process	Typical losses (%)
Batch preparation/weighing of ingredients	2–5
Baking (moisture loss)	10–12.5
Machine washing	2–5
Accidental product breakage	2–5
Rejected packs	2–5

Table 3.2 Typical losses during baking

Case study 3.6 Calculating weights of ingredients from a recipe

Sales of ginger biscuits are expected to be 150 per day, each weighing 33 g (5 kg total). Baking losses are 10% and the weight of dough required = 5 + (5 x 10%) = 5.5 kg.

Recipe	Calculation	Amount needed to make 5.5 kg
Flour: 170 g	(170/436) × 5.5	2.15 kg
Baking powder: 2.5 g	(2.5/436) × 5.5	32.00 g
Sugar: 90 g	(90/436) × 5.5	1.14 kg
Water: 80 g	(80/436) × 5.5	1.00 kg
Fat: 81.5 g	(81.5/436) × 5.5	1.03 kg
Ginger: 12 g	(12/436) × 5.5	150.00 g
Total 436 g		**5.50 kg**

Equipment

Types of equipment

The basic equipment needed in all bakeries is a mixing bowl, containers for dough or batter, hand tools such as spoons, jugs etc. and an oven. However, except at the smallest scale of production, this level of manual operation will be inefficient, hard work and unprofitable. For most small bakeries the following is the minimum level of equipment needed to maintain a profitable level of production:

- weighing scales
- electric dough mixer
- dough divider (for cutting pieces of dough of equal weight)
- oven
- prover
- work tables.

At a larger scale of production the following additional equipment is also used:

- ball moulder (or 'umbrella' moulder) used for preparing dough into ball shapes
- biscuit moulder for pressing or cutting biscuit dough into required shapes
- mechanical dough divider
- bowl hoist to raise mixing bowls to the feed hopper of a dough divider
- pastry brake for rolling pastry dough into progressively thinner sheets
- conveyor belts to transport dough or baked goods between different stages in a process
- final moulder for rolling and pressing dough before placing in baking tins
- packaging machines
- backup generator.

The most important items of equipment for a small-scale bakery are described in more detail in the following section. Details of other equipment can be found in references in the bibliography. Bakeries also need to have a selection of the hand tools shown in Table 3.3.

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. Specially shaped tins for speciality breads
Bread slicer	For cutting bread into slices of uniform thickness
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, or dough awaiting oven space. May be fixed or fitted with 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
First-aid box	Materials for treating cuts and burns
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, scoops, spoons	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 and bag	A small set for cake decoration and a large set for depositing batter onto baking 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	0–1 kg for minor ingredients, 0–50 kg 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. Special sugar thermometer for testing the temperature when making sugar confectionery
Waste bins	For hygienic temporary storage of waste materials. Separate containers for food waste and packaging waste
Whisks	For beating batters

[1] *Different metals are used to make baking tins, trays, cake hoops and cake tins. Black sheet iron has a surface that has partial rust resistance and a high degree of heat transfer. Tin plate should be placed in an oven for at least three hours to make the surface dull (the temperature should not be too high or the tin plating will melt). Aluminium conducts heat well, is lightweight and resistant to corrosion, but is more expensive than the other metals. Electro-clad tins are made from 22 gauge steel that is heavily coated with tin. The matt surface does not need conditioning as does tin plate, and it more easily releases the product.*

Table 3.3 Hand tools and small items of equipment used in a bakery

Design and construction of equipment

Principles of hygienic design and methods of construction for food processing equipment are described in Volume 1 (section 5.3). Doughs and some types of fillings are able to support the growth of food-poisoning bacteria, and any equipment that is used to prepare these foods should be designed and constructed so that it can be cleaned easily. Any build-up of food in cracks, joints or recesses will rapidly become contaminated and infect subsequent batches with micro-organisms. Because of the regular washing that is needed, preparation equipment cannot be constructed from mild steel, and stainless steel, aluminium or plastic should be used. A potential difficulty for ACP bakers is locating stainless steel equipment because stainless steel welding skills and facilities are often not available locally.

Mixers

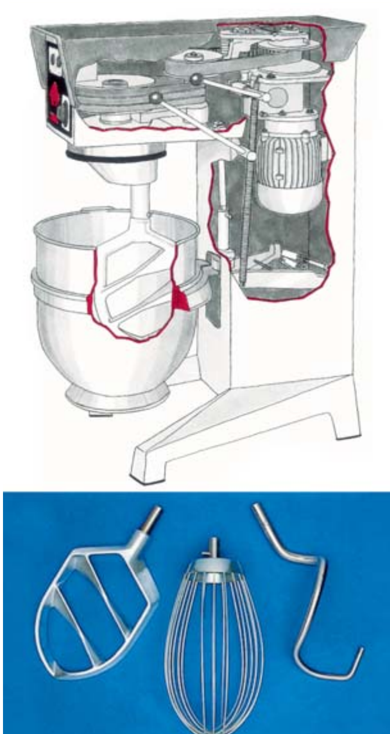


Fig. 3.16 Planetary mixer and attachments (Photo: courtesy of A/S Wodschow & Co.)

All doughs and batters have to be mixed thoroughly to produce a smooth consistency. Mixing small amounts can be done manually or with simple hand-operated machines, but a powered mixer is needed to make sufficient quantities for a profitable business. When selecting a mixer it must have the following features:

- ability to mix different types of product
- sufficient capacity to meet the intended rates of production
- a hygienic design in which no oil or grease from the motor/gearbox can contaminate the product
- good mixing efficiency to produce an acceptable product in a short time with minimum energy consumption
- adequate safety features to protect operators from trapping their hands in the mixer or receiving electric shocks

- mixing bowls should have a smooth internal surface without corners, and all welds should be ground to a smooth finish.

Dough or paste mixers knead the dough against the bowl wall or fold unmixed food into the mixed part. Planetary mixers (Fig. 3.16) have capacities from 20–50 litres and are commonly found in small bakeries. They have rotating blades that include all parts of the bowl in the mixing action. Another design has fixed rotating blades, which are offset from the centre of a revolving bowl. Gate blades are used for mixing pastes or blending ingredients, hooks are used for dough mixing, and balloon whisks are used for cake batter preparation or for whipping cream.

Propeller-type mixers are placed in large tanks and are used for mixing thin liquids such as sugar syrups. Although these mixers are relatively cheap, the investment is not often justified. The small amounts of syrups required in most small bakeries can just as easily be mixed by hand.

Machines for kneading, moulding and forming

Kneading by hand can be a tiring task if large quantities of dough are produced, and increasing labour costs in many countries mean that even a small-scale baker must reduce the time spent preparing dough. For many it is no longer economical to prepare dough by hand, however small the business, and a powered kneader is required. After kneading, doughs are divided and moulded into a variety of shapes and sizes. Close control over the size of the pieces is critical to ensure uniform baking to the centre, and to control the weight (for bread this is a legal requirement in some countries, see section 5.4). The method for doing this will depend on the type of product, and there are many designs for dividing and moulding equipment for different products. This section describes the equipment used for bread, biscuits and pies.

Bread dividers and moulders are particularly useful for buns and small loaves that take a considerable time to divide and weigh (or 'scale off') by hand. They cut the dough into accurately weighed pieces, and shape it into the required form. Typical small dividers/ moulders can produce 15–36 dough balls

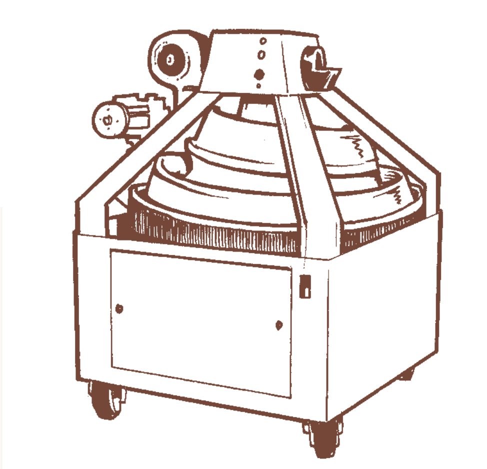


Fig. 3.17 Conical moulder

per cycle, weighing between 18 and 160 g each. A conical ball or umbrella moulder prepares dough pieces into a ball shape by passing them around the outside of a rotating cone and under an enclosing metal track that is located in a spiral pattern around the cone (Fig. 3.17). Differences in speed, angle and shape of the cone, the inclination of the track and the surface finishes are present in a wide variety of moulders. The dough may be dusted with flour to prevent it sticking to the moulding cone. In larger bakeries, this equipment is often combined with an interim prover, where the dough balls drop into pockets on a conveyor and are carried round the prover at a pre-set speed to give the required proving time.

After proving, bread dough is given a final moulding before being placed in baking tins. This can be done by hand, but at larger scales of production the dough is passed through a machine that has sets of rollers with progressively smaller gaps to roll the dough into sheets. The dough is then curled to form the final cylindrical shape. For larger-scale operations, a pastry brake is used to make pastry dough (Fig. 3.18). This has two smooth steel rollers with an adjustable

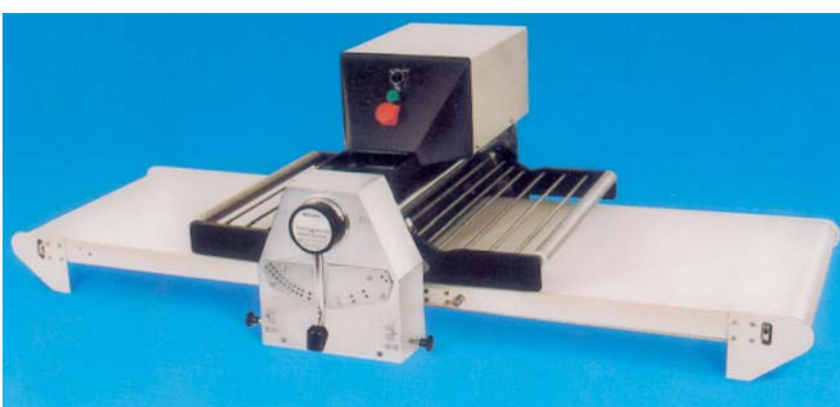


Fig. 3.18 Pastry brake (Photo: courtesy of Electrolux Foodservice Ltd)

gap above a steel table. Dough is fed forwards and back again along the table under the rollers until it reaches the required thickness. Pastry moulds are used in the production of pies, to keep the shape of the dough during baking (Fig. 3.19). Pie casings are made by pressing a sheet of dough into aluminium foil containers or re-usable pie moulds. A filling is then deposited into the casing and a sheet of dough is laid over the top and cut around the edge to form a lid.

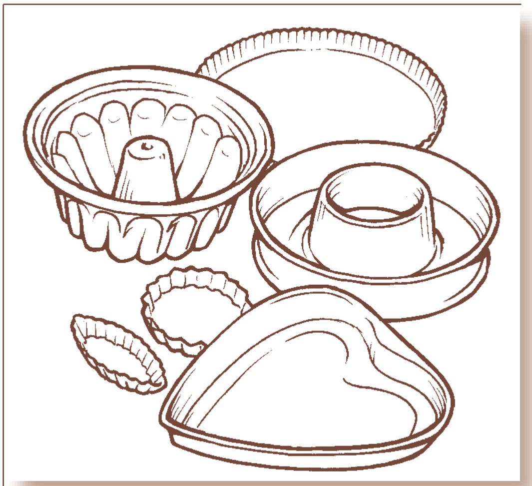


Fig. 3.19 Pie moulds and cake tins

At a small scale, biscuit or pastry doughs are rolled out and cut using either a knife or shaped biscuit cutters. Care is needed to ensure that the pieces of dough are not distorted by handling and that all pieces have a uniform thickness and shape. One way in which a uniform thickness can be achieved is to use pastry bars (Fig. 3.20).

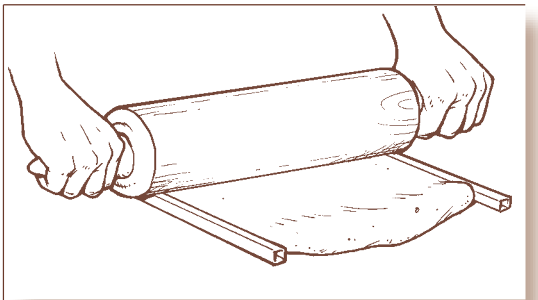


Fig. 3.20 Use of pastry bars

At larger scales of production, biscuits are formed using specially designed rollers, or by extruding the dough through a die and cutting it into slices of the required thickness. These machines require a relatively large investment, but small second-hand machines may be more affordable. Rollers can be the 'die-forming' type, in which dough is pressed into cavities in the roller, or shapes are cut from a sheet of dough using a cutting roller. Raised characters on a printing roller can simultaneously imprint a design on the upper surface of the biscuit.

Provers

Provers are cabinets in which the temperature is raised to 35–43°C and the humidity of the air is maintained at approximately 85%. Provers are used for fermented doughs to enable the yeast to create a raised dough (Chapter 4, section 4.3). Stainless steel cabinet provers from bakery equipment suppliers are electrically heated and expensive, although they give good control over the temperature and humidity. A simple prover can be made using a wooden framework covered in polythene sheeting with a flap to gain entry. The raised temperature and humidity are created by gently boiling a pan of water in the cabinet, and dough is placed on racks for the required proving time. A larger version, created by a baker in Uganda, uses an old steel shipment container that is fitted with a steam pipe from a boiler located outside. The dough is loaded onto wheeled trolleys and the doors are closed while proving takes place.

Ovens

The most important fixture in a bakery is the oven. Many people who are new to baking think that any kind of oven will do for a start, or they choose one that is cheap to construct without considering whether it is also efficient and economical. It is important to choose an oven carefully, taking account of the required capacity and fuel or electricity usage.

In fuel-fired ovens, an arched roof (or 'crown') contains stationary, very hot air that cannot escape through the door. This acts as a reservoir of heat, which maintains the temperature of the crown. Heat is radiated from the crown to bake the products (Appendix I). The more heat that is retained in the crown, the longer the oven can be used before it is necessary to re-fire it. However, the amount of radiated heat that reaches the product is related to the square of the distance between the product and the crown (Fig. 3.21). There is therefore a compromise to be made in oven design between having a large amount of heat retained by a high crown and a smaller amount of radiated heat reaching the products.

When an oven uses a lot of fuel or loses heat quickly due to poor construction, the accumulated cost of wasted heat may turn an otherwise profitable business into one that fails. Although nearly every oven builder

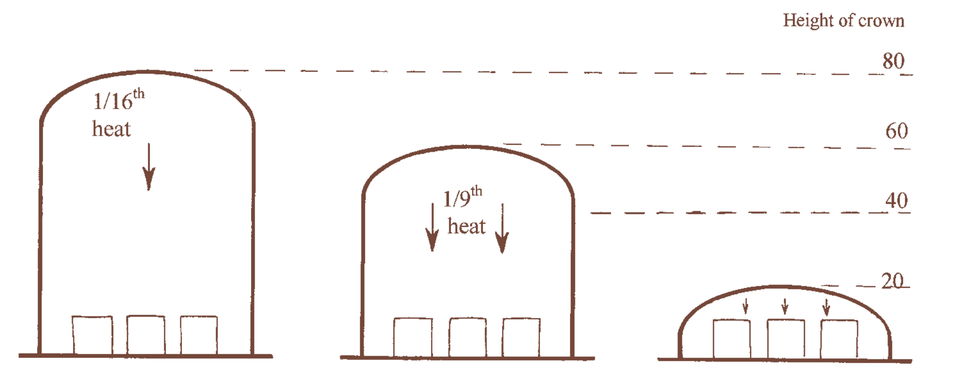


Fig. 3.21 Heat from different oven designs

will say that theirs is the best, a well designed oven should have the following characteristics:

- it should be economical in the amount of fuel or electricity used, and lose little heat
- the temperatures at the top and bottom should always bear a steady relationship to each other, and the oven should bake products uniformly without hot or cold spots
- it should be possible to produce extra 'top' or 'flash' heat when required
- it should have a free flow of air to a firebox or burner assembly, and free discharge of smoke and gases into a suitable flue
- the internal design should ensure that soot, smoke or ash from burning fuels does not contaminate products
- it should be constructed from materials that can withstand intense heat without cracking or breaking
- it should have easy access so that products can be loaded and unloaded without causing burns to operators, and to enable maintenance and repair
- if a product with a glazed crust is required, it should be possible to inject either steam or water into the oven.

There are two categories of ovens: those that are heated internally, and those that have a separate heat source. Internally heated ovens have the advantages of simplicity and a relatively low cost of construction. However, the smoke and gases from the burning fuel come directly into contact with the food and there is an obvious risk of contamination. The simplest oven consists of a brick or stone structure with one opening for the oven door, which also serves as the chimney (or flue). An example is the 'beehive' oven (Volume 1, Fig. 5.5). In this type of oven, fuel is burned on the stone hearth for about 12 hours, often overnight, and the embers are raked out before the dough is baked. There is sufficient heat in the crown to enable baking the next day. Some designs have hollow brick walls that are filled with a mixture of broken glass, sand and/or salt to increase the insulation.

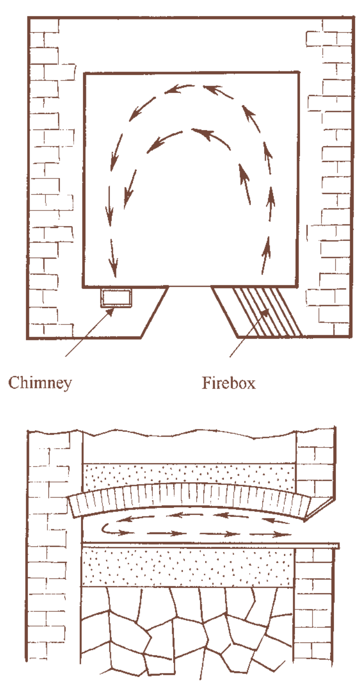


Fig. 3.22 Scotch oven

The 'scotch' oven (Fig. 3.22) has a firebox built into one side of the oven wall and a flue in the opposite side. A damper in the flue controls the intensity of the draught through the fire, and this can also be used to provide flash heat when required. In operation, a low fire is burned overnight to heat the whole structure to a high temperature, and as work starts in the morning the fire is re-kindled. The crown becomes intensely hot and gradually becomes white as the soot is burned off. This heat is then slowly radiated out during the day's baking. This type of oven has a number of advantages, including a high capacity, low fuel requirement, solid construction, longevity and low cost of repairs. The main disadvantage is the production of dust and ash, and skill and care are needed when operating the oven to avoid contaminating the products.

In modern directly heated gas ovens, an insulated steel chamber is fitted with a full-width door (Fig. 3.23). Air and heat are re-circulated by natural convection or by fans. The temperature in the oven is controlled automatically by adjusting the amount of air and gas reaching the burners at the base of the chamber. Safety controls extinguish the burners automatically if the temperature gets too high, and pressure-relief panels are fitted to the top of the ovens to protect staff should a gas explosion occur.

The simplest design of externally heated ovens involves burning fuel beneath a metal chamber (e.g. an oil drum) that contains the products. The food is separated from smoke and ash. This is also the basis of the hotplate or griddle used to bake unleavened breads and other products (section 4.3). Other designs have a baking chamber surrounded by brick- or tile-lined flues leading from a firebox. The flues can have individual dampers, or the oven can be fitted with a single damper in the chimney. The flue allows continuous operation because the fire can be maintained separately without interrupting production; these ovens therefore have a greater capacity than internally heated ones. However, the flue must be carefully designed with an access hatch to enable soot to be removed. The flue lining material must also be able to withstand the intense heat without cracking, which would cause it to collapse.

Fig. 3.23 Multi-chamber gas oven
(Photo: courtesy of Werner & Pfleiderer Ltd)

The reel oven has a steel chamber and shelves inside, which are rotated horizontally by an electric motor. As each shelf passes the door it is loaded or unloaded. The movement through the oven ensures that the products are baked uniformly. A variation on this design is the rotary oven in which the chamber rotates vertically. A full-height door allows trolleys containing trays of product to be wheeled into the oven. These ovens have a high capacity and high cost, and are suitable for larger-scale bakeries.

Electric ovens are fitted with thermostatic controls and safety cut-off switches. They should be fully earthed to prevent the risk of electrocution, and wiring should be properly placed and insulated so that it is not affected by heat from the oven. Three-phase electric ovens should have the load equally balanced across the phases. Most ovens have ceramic tiles as a hearth and the sides and top are insulated with glass wool or a similar material. Modern ovens have energy-saving features and microprocessor controls. For example, operators can select a product code without the need to remember the baking conditions for each particular product. Microprocessors then control the time, temperature and humidity of baking. Small continuous electric ovens are increasingly becoming affordable to small- or medium-sized bakeries (Fig. 3.24). Electric multi-deck ovens (similar in appearance to Fig. 3.23) have a modular construction. The advantage here is that production can be expanded simply by duplicating the modules without having to replace the entire plant. Electric ovens are clean and easily controllable.

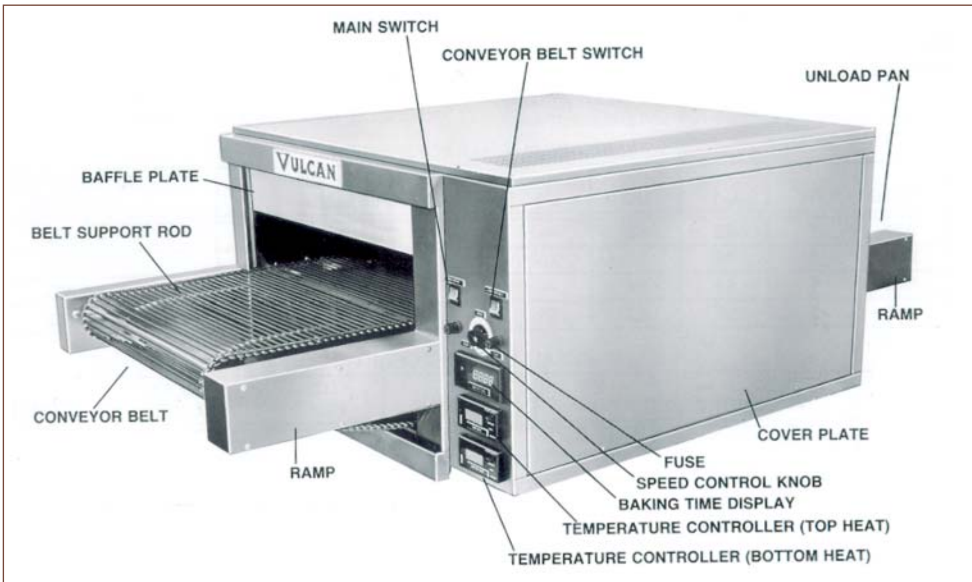


Fig. 3.24 Continuous pizza oven (Photo: courtesy of Oliver Toms Ltd)

Fuels

Theoretically, anything that burns can be used to heat a bakery oven, but in practice, fuel needs careful selection. The cheapest source is not always the most economical. Factors to consider when choosing a fuel include the type and amount of ash that is formed, the energy value of the fuel and the bakery location (to prevent smoke becoming a nuisance) (Case study 3.7).

Case study 3.7 Selecting an oven

'When we started, we used a locally fabricated fuel-wood oven. But as we are tucked in between two business premises, we had to find ways of releasing the smoke without inconveniencing our neighbours. First we adjusted our baking hours, then I tried to improve the oven but the smoke was still a problem. Then we thought about changing to electric ovens, but our advisors told us that they are not suitable for our kind of business as they are too expensive. So now we are trying to find more suitable premises for our wood ovens.'

Specific local conditions in each ACP country determine which fuel has the lowest cost and the greatest availability or convenience (e.g. significant cheap coal reserves, extensive forest cover for wood or charcoal production, hydro-electricity or natural gas reserves). When solid fuels are used, the skill of the baker in controlling the fire is important. A careless or unskilled oven operator wastes large amounts of fuel. Where available, coal is the preferred solid fuel for bakery ovens because it is dense and compact, it has a high calorific (heating) value, it is handled relatively easily and it produces a compact ash that is more easily disposed of than wood ash. Traditionally, wood has been cheap or free and hence widely used in bakery ovens. However, deforestation has resulted in increased cost and legal restrictions on the use of wood in many ACP countries. Wood produces a light fluffy ash that can easily contaminate products, it has a lower calorific value than coal and it requires more labour to prepare it for use in ovens. Charcoal is more expensive than coal, but it produces an intense heat with little smoke. However, restrictions on charcoal burning may apply in areas that are suffering deforestation. The planting of fast-growing fuel-wood trees should be encouraged in such areas. Bottled gas (liquefied petroleum gas, LPG) is available in some urban centres, and where distribution is well established this fuel may be cheap enough to compete with solid fuels. In general, 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 should not be used under any circumstances to heat bakery ovens because of the risk of explosion.

Energy conservation

Clearly, it is in the financial interests of both bakers and millers to reduce energy consumption as much as possible (Case study 3.8). This can be done by careful production planning (Chapter 6) so that mills are only switched on when they are needed, or a sequence of different products are loaded into ovens as they cool, in order to use all the available heat (see Chapter 4, Table 4.8).

Other measures to reduce energy consumption include switching off lights when a room is not in use, and reducing vehicle use by co-ordinating deliveries of products with collection of raw materials. Although these measures may seem minor, their cumulative effect can be significant. Bakeries in particular use large amounts of energy, and reductions in energy consumption can also result in national environmental and economic benefits by reducing deforestation and importation of fuels.

Case study 3.8 Energy saving

Mrs P. in Uganda recognises that there is a high level of competition in the bakery industry. 'I have many competitors, and I know that the recent hike in electricity tariffs has forced some of them to cut down on production, while others have given up completely. The price rise calls for a bit of innovation and for people to give up the mentality of earning 300% profit and settle for a little less. This is a difficult time and you have to be very careful, but if you have invested resources and time in your business then there always ought to be a 'Plan B' for the business to survive. I have reduced my costs by saving energy wherever I can and as a result I still have a successful business.'

Bread slicers

Manual bread slicing using a knife is too time-consuming, even for the smallest bakery, and the slices have a variable thickness. Small electric bread slicers (Fig. 3.25) are the only realistic option for small-scale bakers who wish to supply sliced bread. They produce slices that have uniform thickness and they hold the slices together ready for packaging. Breadcrumbs that are produced by slicing machines do not have to be wasted – they can be collected and sold to domestic customers as a cooking ingredient, or to other food manufacturers as a filling for sausages or a coating for fried products.

Fig. 3.25 Bread slicer (Photo: courtesy of Treif Maschinenbau GmbH)

Packaging machines

Most products supplied by small-scale bakeries are not packaged, except to protect them from dust and other contaminants. Simple bags are sufficient for bread, buns, pastries and small cakes, and these are usually filled by hand. Small machines are available to hold open the mouth of a bag while it is filled, and a tape dispenser is a simple but effective method of reducing the time taken to seal bags.

Products such as biscuits that require more sophisticated packaging for a longer shelf life can be packed in paperboard cartons that have plastic inserts to hold the biscuits in place and prevent damage during distribution. The biscuits are filled by hand and the carton is then covered with a moisture-proof and airtight film, such as cellulose, polyester or polypropylene, and heat-sealed. The other main method of packaging biscuits is to use a tightly fitting film that holds the biscuits together and protects them from moisture, air and light. This type of packaging material is cheaper than cartons, and the production costs are therefore lower. However, the biscuits are filled by hand because of the high capital cost of handling equipment that is needed to prepare the biscuits into stacks ready for packing.

Sources of packaging and ingredients

Most common ingredients that are used in bakeries can be obtained reasonably easily, especially if a large number of bakeries exist in a particular country. Bakers' yeast, baking powder, shortening, oils, and some types of food flavourings and colours can be obtained from larger supermarkets in capital cities or specialist import agents. 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.

The lack of locally produced plastic films and glass or metal containers is a major constraint on the production of biscuits and other long shelf-life bakery products (Case study 3.9). The only option for many producers is to import packaging from a more industrialised country. However, even when an overseas supplier is located, there is usually a minimum order size that far exceeds the annual production capacity of a small-scale baker, and this effectively prevents the manufacture of these products. In some countries, import agents have begun to stock a range of packaging materials, and are able to sell these in smaller quantities to local bakers.

Case study 3.9 Finding packaging materials

A baker in Uganda uses plastic bags and silver foil to package his biscuits and cakes and obtains his materials locally. 'Sometimes we buy cake cartons from a supplier in town and charge it back to the customer. This is normally for birthday or occasional cakes. I have just identified a good supplier in Kenya, but I am still trying to work out transportation so that I just call and have a delivery when I run out. I am seriously thinking of starting to package my biscuits. I considered using tins, but I have not found a reliable supplier as yet.'

Summary of the chapter

✔ Select a good location close to your customers for your bakery

✔ If you own a mill, you have a choice between being close to your raw materials or close to your customers

✔ Make sure that the building is adequate for your present needs and planned expansion. Pay particular attention to removing dust, maximising ventilation and keeping insects and rodents out

✔ Always look at different options before buying equipment

✔ Check that equipment has been hygienically designed and is easy to maintain and clean

✔ Place equipment so that there is space to work and also space to maintain and clean it

✔ Ensure that all machinery is safe to operate and that all guards are in place

✔ For bakers, select the best fuel for the oven; this is not necessarily the cheapest

✔ Invest in ways to save energy

Entrepreneur's checklist

❑ Is your business location the best that you can afford?

❑ Is the building adequately protected against insects and rodents?

❑ Do you have adequate ventilation to remove dust or heat?

❑ Does your equipment meet your needs? If not, what steps will you take to improve it?

❑ Have you investigated ways to save energy?

❑ Is the layout of equipment satisfactory? How could it be improved?

❑ Are all guards in place on your equipment and are all safety features operational?

Readers' notes

Please use this space to make your own notes on Chapter 3.

3

Processing

4

4.1 Developing new products

An important characteristic of successful millers and bakers is their ability to look constantly at their markets and develop new products to meet their customers' needs. This often involves making simple modifications to an existing product, such as introducing a new flavour in a range of cakes, or a new mixture of cereal and legume flours. Sometimes consumers have not seen a product before, but an enterprising processor anticipates that it will be successful. By being the first to produce the new food in a particular area, the miller or baker gains a significant advantage over competitors – even if only for a few months before the product is copied by others. Examples of businesses that have achieved success by introducing new products are given in Case studies 4.1 and 4.2.

Tips for success

- ✔ Be innovative and create new products
- ✔ Make sure you have the correct equipment for the job
- ✔ Be careful to process products in exactly the same way every time
- ✔ Even if your business is very small, learn from the professionals and let them mentor you. Call in an expert if things seem to be going wrong
- ✔ Always go for the best deals – no supplier is indispensable
- ✔ **Finally:** Read sections 2.1–2.5 in Volume 1: *Setting up and running a small food business.*

To develop successful new products, millers and bakers must understand both the markets in which they operate (see Chapter 2) and the materials and processes they use. This is because they need to have a very clear idea about the characteristics of the new product they wish to make and what consumers will like about it. But they must also be able to reproduce those same characteristics in every batch. This requires a good understanding of the way the product is made, and an ability to adjust the ingredients and processing conditions to take account of natural variability in raw materials. They must also be able to create the time and resources needed to test out their ideas.

The eight stages in product development can be summarised as follows:

1. Decide the type of product to develop and the precise characteristics that are required

↓

2. Select or develop the recipe or formulation

↓

3. Obtain all the raw materials and equipment required

↓

4. Make test batches of the new product

↓

5. Evaluate products to see if they have the characteristics consumers want

↓

6. Carry out shelf life / storage trials

↓

7. If necessary, modify the recipe or process to produce a better product

↓

8. If necessary, adjust the process for full-scale production.

The equipment required to develop new products is the same as that used in the mill or bakery, together with a calculator and accurate scales. For product development work it is necessary to weigh materials accurately. These weights can later be converted to other measures for routine production (e.g. scoops and jugs that are calibrated to known volumes are cheaper and faster to use than weighing with scales). It is important to check that scales are accurate and correctly zeroed before starting work. Weigh the container of ingredients (to an accuracy of ± 1 g) before starting, and re-weigh it afterwards to calculate the amount of material that has been used. It is very common for an excellent product to be developed, only to find that the processor is not sure how much of a particular ingredient was added and so cannot repeat the product.

A word of warning: although new product development can bring significant benefits to a business, it is also a risky venture. A high proportion of new products fail, even in the best companies. Be careful not to over-spend resources (both time and money) in developing a new product unless you are certain of the consumer demand.

Case study 4.1 New products from a miller

A Ghanaian teacher, who has always had a passion for business, went into maize and bean farming in 1995. She conducted an informal market survey to assess which maize products had the greatest added value and economic potential. She found that most people would like to have a ready-made local breakfast cereal, instead of imported cereals like corn flakes. So in 1996 she decided to go into the cereal business. She undertook on-the-job training with traditional processors and experimented with different recipes. With financial support from her husband and her own resources, she secured start-up capital of US$300, and bought a corn mill, a gas stove and utensils to produce maize grits and soyabean flour. She used the family van to go door-to-door to sell her products to supermarkets and schools, and also did demonstrations to introduce her products. The maize grits were so popular that she was able to repay the cost of the mill in two years.

She now operates a profitable business supplying petrol station supermarkets and other exclusive shops in affluent suburbs of Accra, Kumasi and other large cities. She also sells to busy women executives and workers in private and public organisations, and to institutions such as schools and hospitals. She employs six full-time staff and takes on extra temporary hands when she gets a lot of orders. She has increased the range of products to include baby mix, *fufu* powder, rice flour, cereal mix, spinach powder and pepper powder. Nursing mothers from all socio-economic backgrounds buy her soyabean flour, which is promoted by the Child and Maternal Health section of the Ministry of Health. The maize grits are very popular with busy working mothers who like to create variety in the family breakfast without having the laborious process of making it.

Case study 4.2 Product innovation by a baker

A home economics graduate in Ghana started baking and selling pies, pastries, biscuits, bread and especially cakes, initially for friends' parties. She also baked speciality products for vegetarians and for people on low-fat or gluten-free diets. The demand for her products kept increasing, so in 1994 she decided to bake on a bigger scale and sent samples to up-market supermarkets for their opinions. She was surprised at their demand for her bread and biscuits, so she decided to increase the number of days she baked from two to four days per week. She had a full-time job, but found that she could double the production capacity when she had a day off from her work. To meet the growing demand, she invested US$30 of her savings and bought a bigger second-hand oven at an auction, and started baking 48 loaves a day in her kitchen. She also employed her son and two of his friends part-time. Business was good but she could only produce 60 loaves a day because of the size of her oven.

In 1999, some missionaries visiting Ghana bought her wholemeal bread, breakfast cereals and biscuits, and were so impressed with their quality they wondered why she did not produce more. She told them of her need for bigger ovens and the church decided to give her a micro-loan of US$2,000 to buy three large ovens.

She now supplies bread, cakes and breakfast cereals to supermarkets, shops at petrol stations, and to families who are on vegan or restricted diets. Most of her customers are wealthy people who care about their diets and are prepared to pay for good food. She is very innovative and is always looking for new ideas or formulating new recipes to out-class her competitors. She has developed different products for different markets (for example, garlic bread for restaurants, honey instead of sugar for diabetic bread, and soya flour as a substitute for wheat flour in gluten-free recipes). Her success has been due to making sure that she produces new recipes and products to meet her customers' needs. She has now decided to focus on composite bread and vegan foods, for which there is a large and growing demand.

4.2 Grains and flours

Although there are fewer opportunities for developing new milled products than for bakery products, product development can still significantly improve the income and profitability of milling businesses. The six main areas in which developments are possible are:

1. Diversifying into packing whole grains
2. Developing new combinations of flours, sometimes for specific markets such as infant foods
3. Designing new packaging or pack sizes to meet identified consumer needs
4. Producing improved quality flours
5. Manufacturing dough or porridge from flours
6. Creating new uses for by-products.

Improved packaging is described below and improvements to product quality are described in Chapter 5 (section 5.2).

The types of milled products can be grouped according to the processes that are used (Fig. 4.1). Development of each of the different products is described below.

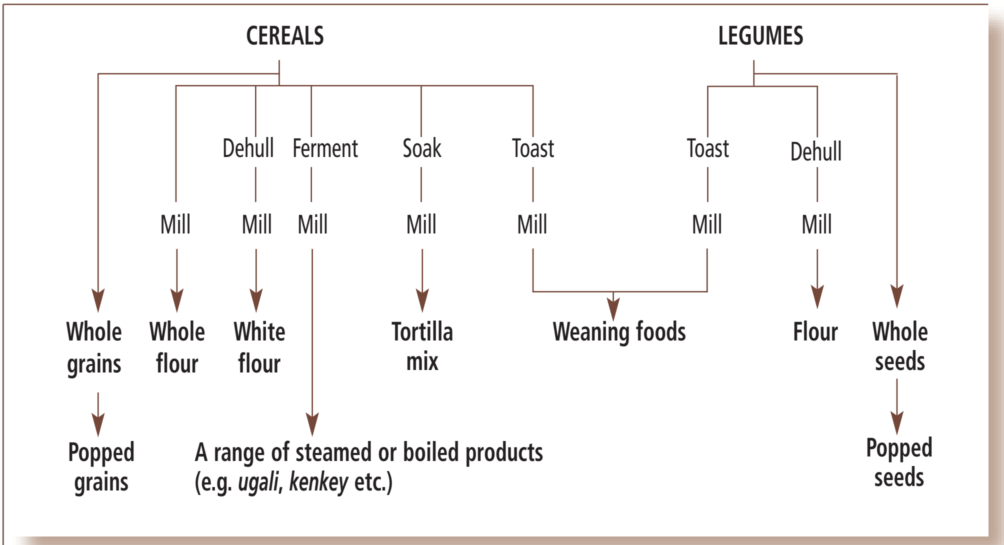


Fig. 4.1 Types of products that can be produced by a small milling business

4

Whole grains and legume seeds

Milling businesses can diversify by simply cleaning and packaging dried whole grains and pulses. They need little additional equipment and, consequently, the required investment is low. However, the products are in competition with the whole grains and pulses that are sold loose in retail markets at a relatively low cost. Because processors incur additional costs for cleaning and packaging, they must use the higher quality as the main selling point to justify the higher price and cover the additional costs. The packaging and promotional materials can place particular emphasis on the product being hygienically produced and guaranteed free from dirt or stones.

Value can be added to whole grains or legumes by popping them to make snackfoods (e.g. popcorn or popped sorghum). This can be done on a small scale by heating the moistened grains in very hot sand (at 180–200°C) and then separating the grains from the sand using a metal sieve. On a larger scale, special 'popping guns' are available. Similarly, parboiling rice in hot water for 4–48 hours, followed by drying, improves the quality and yield of rice grains, and thus adds value to the crop. The process loosens the bran layer and toughens the grain, giving higher hulling efficiency, increased machine capacity, reducing breakage and extending the life of machine components. However, parboiling also changes the colour of rice from translucent white to a cream or yellowish colour, depending on the parboiling time and temperature. The acceptability of the colour change should be checked with potential customers before the process is introduced.

New types of flour or combinations of flours

Most millers concentrate on one type of cereal flour as their main business. If the demand exists, there are good opportunities to diversify into other types of flours, producing them using the same equipment (see Case study 2.7 on page 31). A range of products can be packaged under the same brand name, and this can help to increase sales of the main product by creating greater awareness among customers and increasing their confidence in the company as a serious producer. The range of products can include whole-grain flours, white flours made from dehulled grains or legumes, and mixed flours for specific applications or specialist markets. The only product development work that is required is to establish the correct settings or change the screens on seed cleaners, dehullers and/or mills to accommodate the new grains or legumes. Additional resources are required to establish new and reliable sources of raw materials and to create new packaging and promotional materials.

Weaning foods

Young children require an adequate supply of protein, energy, vitamins and minerals to ensure normal growth and development. Most young children in ACP countries are weaned using porridge or pap made from locally grown ingredients (Table 4.1). Details of infant nutrition, nutritional deficiencies and the nutritive values of different foods are beyond the scope of this book and further information is given in nutritional texts in the bibliography.

4

Composition	Amount required per day (g)
Basic gruel	
Cereal flour	150
Oil	25
or sugar	50
Water	1000 [1]
Additional ingredients required to provide sufficient protein	
Dried whole milk	20
Dried skimmed milk	10
Fish flour (cook with gruel)	8
Groundnut flour or ground sesame seed (omit oil)	20
Bean flour (cook for longer)	25

[1] *May be adjusted up or down by 20% to achieve the required consistency.*
Supplementing with mashed fruit and vegetables provides Vitamins A and C. Other vitamins and minerals can be added using a vitamin–mineral mix.

Table 4.1 Some formulations for weaning foods that meet the energy and protein requirements of a 7 kg infant (adapted from *Mitzner et al.* 1984)

The main problem for a miller who wishes to make an infant weaning food is to ensure that the combination of nutrients is adequate and balanced. In particular, the amino acid content of proteins is different for cereals and legumes. Alone, neither cereals nor legumes contain the full range required for a child's healthy growth and development, but by combining them in the correct proportions, it is possible to correct the deficiencies in each. Legumes contain anti-nutritional substances that must be destroyed by cooking, a process that also makes them more digestible.

Weaning foods are made from cereal and legume flours by:
- weighing the correct combination of raw materials
- (for some) toasting cereals and/or pulses to remove anti-nutritional factors and increase their digestibility
- milling to produce the required particle size
- (for some) blending in a vitamin–mineral mix
- packaging as a dry mix.

These products are made into porridge by adding water, together with additional nutrients (especially protein) that are not present in the flours in sufficient amounts. Other products can be made by baking the mixture into biscuits, which are then broken up and mixed with water or milk to form a gruel. Another method of producing weaning foods is to use an extruder. Details of extrusion technology are outside the scope of this book and readers should consult references in the bibliography for further information.

> *It is essential to obtain nutritional advice before developing or marketing weaning food products. Any new weaning food must be tested by the Bureau of Standards, Ministry of Health or other relevant regulatory body, to ensure that it is safe to eat and nutritionally balanced to maintain the health and growth of the child.*

An example of a specification for a high quality weaning food is given in Table 4.2. Millers who wish to develop these products should consult the organisations listed in Appendix II and the bibliography for advice.

Test	Minimum	Maximum
Bulk density (g/cc)	0.55	0.75
Moisture (%)	–	10.0
Protein (%)	16.7	–
Fat (%)	6.0	
Fibre (%)	–	2.0
Energy (Kcal/100 g)	375	
Total bacteria [1]	–	50,000
Aflatoxin (ppb) [2]	–	20
Particle size distribution:		
US No. 6 screen (% pass)	99	–
US No. 30 screen (% pass)	–	92
US No. 60 screen (% pass)	–	60

[1] *No* Salmonella *spp.,* E. coli *or* Staphylococci *spp. should be present*

[2] *Poisons produced by certain types of moulds (ppb = parts per billion)*

Table 4.2 Specification for a high quality weaning food (adapted from Mitzner et al, 1984)

Porridges

A wide range of thick porridges and similar products are made from maize, sorghum and other cereals. These are staple foods and are also sold as streetfoods in many ACP countries (*e.g. ugali, fufu, agidi, banku* and *tuwo* in West Africa). Some are simply flour and water pastes, whereas others are fermented to produce natural acidity (e.g. balls of Ga *kenkey* in Ghana and *bagone* in Botswana), or made alkaline using potash (e.g. *Tô* in Mali), or acidified using water that has been used to soak tamarind before cooking.

The general procedure for making porridges is to mix part of the flour in water and add this to boiling water. It is then cooked to thicken it. After cooling, the remaining flour is added with vigorous stirring and it is re-cooked for a few minutes. *Kenkey* is made by wrapping the fermented dough in leaves and steaming it for several hours. It is eaten by tearing off small pieces and dipping them in a sauce. Details of processing these products are beyond the scope of this book, but further information can be found in Kordylas (1990) in the bibliography.

New uses for by-products

Bran is the main by-product produced by milling, and in some ACP countries it has little value and is allowed to accumulate outside the mill. This attracts insects and rodents, and therefore not only creates a health and environmental hazard, but also increases the risk of product contamination inside the mill. Millers often have to pay to have the bran removed to a disposal site, especially in urban areas, which increases the operational costs of the mill. There are a number of options to change this operating cost into an additional source of income. Bran may be sold to local chicken or egg producers to be used in poultry feed, or to livestock farmers as a component of ruminant feed, especially where zero grazing is practised. If a miller is willing to make an additional investment, a separate feed mill can be established to use the bran as a component of pre-prepared and packaged animal feed. Details of the operation of feed mills are given in references in the bibliography.

More novel uses of bran include:
- making fuel briquettes to replace charcoal for domestic cooking
- compressing the bran with glue as an alternative to wood for furniture making
- using bran as a reinforcing material to strengthen concrete blocks.

Details of these applications are outside the scope of this book, but readers are referred to the bibliography for further information.

Packaging and storing flour

Flour can be satisfactorily packaged in small amounts in paper or polythene bags, or in bulk in polypropylene, cotton, multi-wall paper or hessian sacks, each of which are available in many ACP countries. Heat sealers are used for polythene bags, while paper, hessian and polypropylene can be sealed using a sack stitcher (Fig. 3.14).

4.3 Bakery products

Selecting a product and a recipe

Successful and innovative bakers understand the markets in which they operate and know what their customers want (Chapter 2, section 2.3). They think about how they can meet their customers' needs, and then either consult recipe books or use their own knowledge to develop their product ideas. After modifications to allow for local availability of ingredients or for local tastes, they then test the new products on friends and customers. If the products are well received the baker will go ahead and develop successful new products for the market.

Because of the very wide variety of ingredients and baking techniques that can be used, baking offers the potential to produce a huge range of different products. These include buns, breads, biscuits, flans, pastries, pizzas, pies or cakes (Fig. 4.2), each with the possibility of having different shapes, colours, flavours and sizes. It is not possible in a book of this size to describe in detail the production of each of these products. Instead a description is given of the processes that are used for each product category, and the different ingredients are summarised in Table 4.7 (page 114) for bread, Table 4.11 (page 126) for flat breads and biscuits and Table 4.12 (page 133) for flans, cakes and pastries.

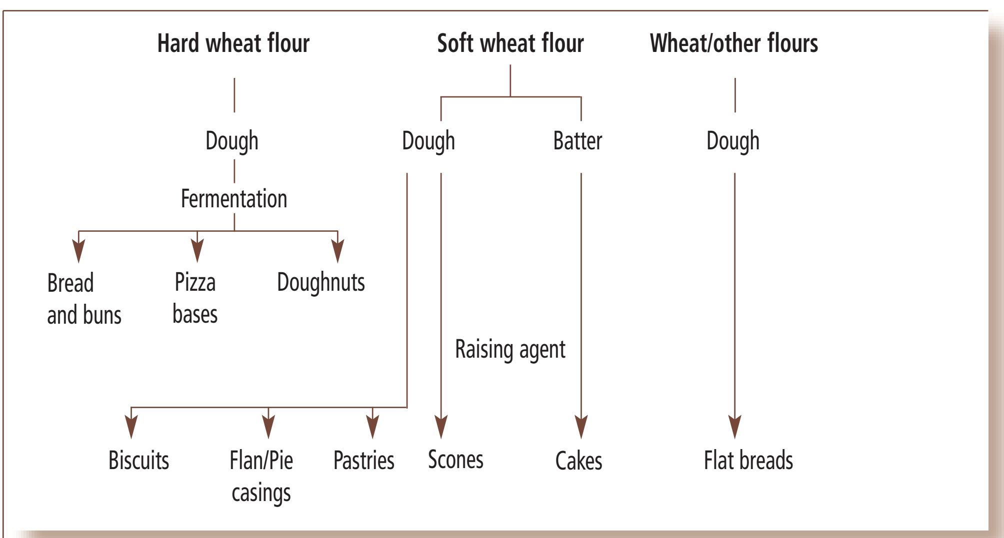


Fig. 4.2 Types of bakery products

Selecting ingredients

All bakery products are made from a set of basic ingredients, which contribute to their quality and properties in different ways (Table 4.3). Basic ingredients are often supplemented with others to give special flavours, colours or textures; for example dried or fresh fruit, flavourings and colourings, fresh vegetables, meat, nuts, spices, chocolate or cream.

> *Good quality ingredients are needed to make high quality baked products. 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 (section 5.3) are needed to be sure that only the best ingredients are used.*

Ingredient	Function
Flour	Proteins in flour combine with water to form gluten, which contributes to the structure and helps to retain gas in raised baked products. Starch in flour combines with water to form a paste that is set by heat during baking. Changes to starch structure occur during storage and cause staling.
Yeast	Produces carbon dioxide to raise doughs, contributes to dough conditioning, forms flavour by-products.
Salt	Helps control yeast fermentation, toughens dough by interacting with gluten, extends dough development and mixing time.
Sugar	Used by yeast in fermentation, sweetens dough, contributes to browning during baking, tenderises crumb and extends shelf life.
Shortening (fat)	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 doughs.
Pre-mixes	Reduce dough preparation time; ensure even mixing of small amounts of ingredients, help to avoid operator errors.

Table 4.3 Summary of functions of main bakery ingredients

Flour

Wheat flour is required for most baked products because it contains gluten, a protein that creates the characteristic crumb structure of bread and influences the texture of other bakery products (Appendix I). Wheat flours are either 'strong' (made from 'hard' wheat) or 'weak' (made from 'soft' wheat). Strong flours have a higher gluten content and absorb more water than weak flours. In many ACP countries, the protein content of flours can be variable and flour may be incorrectly labelled. It is essential that bakers are able to distinguish between the two types because weak flour cannot be used to make bread successfully. A simple test for gluten content is described in Chapter 5 (section 5.3).

Flour mills produce different grades of flour, each described by their extraction rate (the amount of starch extracted from the grain). The most commonly used white flour in bakeries is 'straight-run' flour, which contains 76–78% of the original wheat (Table 4.4). Special patent flours produce cakes and sponges that have a brighter, glossier crumb texture than those made using straight-run flour.

Wholemeal and whole-wheat flours are made when the whole of the grain is ground. They have a shorter shelf life than white flour and require less proving because they contain enzymes that ripen the dough more quickly.

Type of flour	Description	Extraction rate (%)	Bran and germ (%)	Examples of uses
Wholemeal/ whole-wheat	The whole grain, including the germ and bran	95–100	0–5	Bread
Wheatmeal	Straight-run, containing the bran	85–95	5–15	Brown bread, rolls, and other high-fibre products
White	Long patent	95	5–60	White bread, rolls, pastries, cakes
	Medium patent	90		
	Short patent	70–80		
	Extra-short or fancy patent	40–60		

Table 4.4. Different types of flour

Other types of flours include brown flour, which is white flour with some of the bran added back, and granary flour, which is made from a mixture of wheat and rye grains that have been allowed to sprout and then dried. Self-raising flour has added baking powder and is used for cakes, biscuits and scones. However, it is not recommended for commercial bakers because it loses its raising ability when stored for long periods. It is better to use plain flour and blend in the required amount of baking powder for the specific product, as it is needed. Cornflour is a fine white starch made from wet milling maize, which forms an opaque gel when boiled with water. It is used to thicken all types of sauces, glazes and custards, and is also an ingredient in some cake mixes. Arrowroot flour is almost pure starch extracted from the arrowroot plant. It has similar properties to cornflour, but forms a clear gel and is therefore preferred for glazes.

Cassava, millet, rice, tef, sorghum or maize flours may be used as a partial substitute for wheat flour, especially in ACP countries where wheat is not grown in significant quantities. Using local resources keeps costs down by reducing use of expensive imported wheat flour. However, as these flours do not contain gluten, they cannot be used to make bread at more than approximately 25–30% of the total weight of flour. At a higher proportion, emulsifiers or changes to the bread-making process are needed (Table 4.5). Above this level, the loaf volume and shelf life are reduced and differences in taste and texture become very noticeable. Non-wheat flours can be used in cakes and biscuits because these products do not rely on gluten to the same extent as bread for their texture. Sorghum flour is also used instead of maize in more arid ACP countries to make similar porridges and doughs (*ugali, uji, chapati, injera etc.*) and snackfoods. Soya or composite flour is usually made from maize and soya flour, although other cereal flours can be mixed with the soya flour. A variety of bean flours can also be used in composite flours, including those milled from peas, broad beans or chickpeas.

Type of flour	Level of substitution (%)
Sorghum	15–20
White sorghum	30
Millet	15–20 (30% if addition of millet flour is delayed until the end of dough mixing, or sugar and fat content is increased to 4% each, or improvers are used)
Maize	20–25 (with an increase in water addition by 2% for each 10% substitution and an increase in amount of yeast by 1.5 times the standard weight)
Rice and soya	27 + 3 (with dough improver)
Rice and cassava	10 + 40
Rice starch	25
Soya	30–40 (the high protein and reduced carbohydrate content is suitable for diabetics)

Table 4.5 Substitution of wheat flour by other flours in bread-making

Researchers have developed different types of wheatless bread, which involve the use of either starch paste or xanthan gum to replace the gluten and create the texture of bread. Rice flour bread (made from 100% rice flour, or 80% rice flour and 20% potato starch) uses carboxyl methyl cellulose to create a crumb structure. Others have used carob gum, guar gum or tara seed gum to provide the bread structure. However, unless it is extremely difficult to obtain wheat flour, it is likely that most small bakers will continue to use traditional flours or composite flours, rather than developing completely wheatless products.

Water

Water must be clean and safe to drink. If there is any doubt about the quality of water, the supply should be analysed by a government laboratory to ensure that there are no impurities that could be harmful. Simple methods for water purification are described in Volume 1 (section 5.2).

The water content of dough depends on the water absorbing capacity of the flour, and a simple test for this is described in Chapter 5 (section 5.3). If the water content is insufficient, a 'tight' dough is produced, and the bread lacks volume and has a heavy texture. Hard water may also create a tight dough or slightly slow the yeast fermentation. Bakers therefore need to know the composition of the water to be able to adjust recipes and process conditions when developing new products.

Yeast

Yeast cells ferment sugars in the dough to produce carbon dioxide gas and alcohol. In baking it is the gas that is important, and the small amounts of alcohol are evaporated by heat in the oven. The specific type known as bakers' yeast can be obtained in three forms: as pressed fresh yeast, dried yeast or active dried yeast. Pressed yeast requires refrigerated storage and loses its activity more quickly than dried yeast. Dried yeast should be activated before use. This can be done by mixing it in five times its weight of warm water with a little sugar and leaving it to stand until the water becomes cloudy and gas bubbles are visible, before adding it to other ingredients. Dried active yeast is added directly to the dry ingredients without the need for activation. Because it is easier to store and has a longer shelf life, dried yeast is more likely to be available in many ACP countries.

However, even dried yeast cells slowly die, and depending on the storage conditions, the yeast may lose 2–3% of its activity per year. In some countries it is very difficult to obtain good quality yeast, particularly outside urban centres, because the yeast is old and has lost some of its activity. A test for yeast activity is described in Chapter 5 (section 5.3).

Adding the correct amount of yeast is critical if good quality products are to be baked. This should normally be 0.3–1.0% of the weight of flour. The other factors that affect the rate of dough fermentation are:

- temperature and water content of the dough
- time of fermentation
- quality of the flour (sugar content and amount of gluten)
- amounts and types of other ingredients.

An experienced baker can take these different factors into account and produce a consistent dough, but because there are so many variables, it is sometimes difficult for a new baker to predict accurately the amount of yeast that should be added in different situations. Similarly, when developing new products the amount of yeast needed to produce a satisfactory product may vary from the amount given in the recipe, depending on local conditions and the processing methods used. Bakers in earlier times used the Imperial system of measurement to develop a formula for calculating the amount of yeast required for dough fermentations of different lengths of time. To use this with metric measurement it is necessary to convert the factor as shown in Case study 4.3.

Case study 4.3 Calculating the amount of yeast to use

Assuming a sack of flour (280 lb) requires 3 lb of yeast and a three-hour fermentation to make a typical dough, the factor is found by multiplying the yeast quantity by the time, i.e. factor = $3 \times 3 = 9$

If a two-hour fermentation is required using the same temperature, the amount of yeast = 9 / 2 = 4.5 lb

To convert the factor to metric, based on 100 kg flour: the amount of yeast in the first (three-hour) fermentation = 3 lb per 280 lb = 1% (approx.)

Therefore the fermentation will require 1% of 100 kg = 1 kg yeast
And the factor then becomes $1 \times 3 = 3$

So a two-hour fermentation of 100 kg 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 100 kg flour fermented over three hours at 26°C the amount of yeast would then become 4.2 divided by 3 = 1.4 kg (or 14 g yeast per kg of flour), and for a two-hour fermentation it would be 4.2 divided by 2 = 2.1 kg (or 21 g 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.

The temperature of fermentation also affects the amount of yeast that is needed and/or the time of fermentation. As a general rule a change in temperature of about 1°C requires a change in fermentation time of 10%. The relationship between dough temperature and the amount of yeast required is shown in Table 4.6.

Dough temperature (°C)	Increase in amount of yeast required
27	–
26	+20%
24	+40%
23	+60%
22	+80%
21	+100%

Table 4.6 Change in yeast quantity with fermentation temperature (adapted from Cauvain and Young, 1998)

Salt

Salt (sodium chloride) should be pure white crystals. Sea salt is more likely to contain impurities, and the more consistent quality rock salt is preferable. Salt easily absorbs moisture from the air, and should be stored in a dry place off the floor. In regions of high humidity it should be stored in moisture-proof containers. Salt has the following functions in bread-making:

- it gives flavour
- it stabilises and strengthens the gluten
- it controls the yeast fermentation which in turn affects the crust and crumb colour
- it helps retain moisture and so reduces staling.

The amount added to a bread dough depends on the type of product, the flour strength, the water content of the dough and consumer tastes. European breads may contain up to 2500 g per 100 kg flour but ACP breads are typically less salty, containing between 1420 and 1785 g per 100 kg flour. Salt must be distributed evenly throughout the dough to prevent it coming into contact with the yeast and killing it. This can be done either by dissolving the salt in water before adding it to the flour, or by sieving the salt into the flour before mixing.

Sugar

Although flour normally contains 2.5–3% natural sugar, in some ACP countries a further 1.5–2% sugar is added to make the popular sweetened breads. Other bakery products, such as pastries and cakes, may contain substantial amounts of sugar. White granulated sugar is suitable for most bakery uses, but pure sugar is sometimes difficult to obtain in ACP countries due to impurities (traces of molasses giving a pale brown colour) or contaminants. Dissolving the sugar in a little warm water and filtering it through a fine cloth or mesh is a convenient way to remove contaminants. Brown sugars are used in some rich fruit cakes as they contribute to the flavour as well as the colour of the product. For rich cakes made using the sugar-batter method, castor sugar should be used. Other types of sugar include icing sugar, demerara sugar, golden syrup, treacle and honey, and each have specialist uses, particularly in patisserie products.

Confectioners' glucose (or glucose syrup) is a thick, viscous transparent syrup made from a mixture of sugars and dextrins (Appendix I). It is characterised by a Dextrose Equivalent (DE) number. Bakers use high-DE syrups in cakes to keep them moist during storage.

Malt

Different types of malt can be added to bread dough, but great care must be taken to avoid problems of quality in the final product. Diastatic malt has natural enzyme activity: it breaks down starch and softens gluten. High diastatic malt is only suitable for short processes and for use with very strong flour. In other baking conditions it produces a sticky crumb and dark crust colour. Low diastatic malt has a less marked effect on the loaf quality, and non-diastatic malt has no enzyme activity, but contributes sugars, flavour and a darker colour to the dough. When used correctly, malts have the following advantages:

- better dough ripening with an increase in gas production and loaf volume
- improved crust colour and bloom
- a softer, lighter crumb
- longer shelf life.

Malts can be obtained as dried malt extract (used at up to 250 g per 100 kg flour), viscous malt extract (used at up to 175 g per 100 kg flour) and malt flour (used at 1430 g per 100 kg flour).

Fats

Fats used in baking include special bakers' fats (or 'shortenings'), butter and margarine. A high melting-point vegetable fat is preferred to animal fat, but vegetable oil is not recommended. Shortenings are produced from a wide range of oils, the most common including palm, sesame, coconut, palm-kernel and cottonseed oils. Cocoa butter and a mixture of fat and skimmed milk are also used. These shortenings are used for all short-pastry products, and may be mixed with margarine or butter in cakes to improve the shortness of the crumb. Butter gives a better flavour but has poorer creaming properties than shortenings. If the flavour of butter is required, it is recommended that 50% of the butter should be replaced with good quality shortening. However, because shortenings are 100% fat and butter is only 84% fat, it is important to use only seven-eighths of the weight of butter when substituting with shortening. In some countries, specially formulated margarines can be found, including cake margarine, pastry margarine (for puff pastry) and unsalted margarine (for use in creams). A good quality margarine that has good creaming properties is necessary for making cakes, to hold the air that is beaten into the batter. Lard is used for savoury pastries, where its flavour is valued, but it cannot be used in cakes because of its poor creaming properties. It also imparts shortness in pastry that cannot be matched by other fats. In theory, fat is not necessary in bread production, but the addition of fat, at 0.5–1% of the weight of flour, increases loaf volume and gives a more tender and thinner crust, a better crust colour, a softer crumb and an improved flavour.

Milk

Fresh whole or skimmed milk, dried skimmed milk, sour milk and buttermilk are used in different bakery products. Dried skimmed milk powder can be reconstituted to liquid milk or mixed in directly with the dry ingredients before the water is added.

Eggs

Although eggs from geese, ducks and other poultry can be used in cakes, it is more normal to use chicken's eggs because they have a less pronounced flavour. They should be fresh (used within a few days of laying) and without visible damage. Whites and yolks should stand bold when removed from the shells. Locally purchased eggs are rarely graded by size in ACP countries, and the egg contents should therefore be weighed to produce a standard recipe. Egg sizes vary widely from approximately 40 g to 60 g. The weight of the yolk is approximately half that of the white. A medium egg (e.g. 53 g) would therefore give approximately 15 g of yolk and 30 g of white after the shell weight is taken into account.

If egg yolks or whites are left standing, they should be covered with a damp cloth to stop a skin forming on the surface, and kept in a refrigerator to restrict the growth of micro-organisms. Dried egg powder is available in some capital cities in ACP countries, but it is only used for cheaper, lower quality cakes. This is because it does not hold air as well as fresh egg. It is reconstituted using a ratio of one part egg powder to three parts water, and should be used immediately to avoid any risk of food poisoning.

Baking powder

Baking powder contains two ingredients: acidic cream of tartar (acid calcium tartrate) and alkaline sodium bicarbonate, in the ratio two parts to one. When the powder is moistened, the ingredients react to produce carbon dioxide. Baking powder can be bought ready-mixed, but it may have lost some activity if it has been stored for too long at a retailer's shop. More preferably, the two separate ingredients should be sieved together just before they are needed to ensure that they are fresh and uniformly mixed. The blended mixture should be sieved into the flour to ensure an even distribution. The mixture can be stored in moisture-proof and airtight containers for a few days. This type of baking powder leaves no after-taste in the product but tends to react rapidly, so these products should be baked quickly. Substitute baking powders based on acid calcium phosphate instead of cream of tartar react more slowly but leave a slight aftertaste when used in large amounts (e.g. in scones).

Flavourings and colourings

Flavourings can be grouped into extracts, essential oils and essences. Extracts are derived from natural materials using alcohol as a solvent. They give the most natural flavours and are often the most expensive. Vanilla is obtained from vanilla pods and the essence is a 10% solution in alcohol. Synthetic vanilla is also widely available. Essential oils are made by steam distillation of spices, roots, peels, nuts or flowers. They can withstand the high temperatures of baking to give flavour to cakes or biscuits. Common types used in bakeries include lemon oil, orange oil, lemon grass oil, citronella oil and peppermint oil.

Essences can be artificial flavourings that resemble natural materials such as lemon, orange, chocolate or vanilla flavour, but are not derived from natural materials. They are cheaper than extracts and essential oils, but do not withstand baking temperatures and are therefore used mainly in creams and icings. Common ones include pineapple, pear and apple. Natural lemon essence contains 5% lemon oil diluted in alcohol and peppermint essence contains 3% oil. Essences and extracts may also be supplied as blends, and as a general rule their quality is directly reflected in the cost. For expensive products, different types of alcoholic spirits and liqueurs, including rum and brandy, may be used to flavour cakes after baking.

Spices are available in two main forms: spice oils and ground powders, although ginger is also available preserved in syrup. Others used in bakery include oils of anise, cloves, coriander, cassia, cinnamon, caraway, ginger, mace and nutmeg. Colourings can 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.

Dried fruits, including sultanas, currants, apricots, raisins and mixed fruit peel, are used in buns and cakes and fresh sliced or chopped fruits may be used in tarts and pies. Commonly used nuts include almonds, brazil nuts, groundnuts, dried coconut, pistachio nuts, walnuts and pecan nuts. They may be used whole, as halves or chopped. Marzipan is made by steaming a mixture of one part sugar and two parts almonds and grinding the mixture to a stiff paste. Praline paste is made by milling nuts (usually almond or hazelnut, although any nut can be used) using steel rollers. Both marzipan and nut pastes form a skin when exposed to air and should be stored in plastic bags for a short time before use. They are very prone to mould growth and therefore should not be stored for long periods.

Other ingredients

Crumb softeners are additives that can be used in bread-making to soften the crumb, although these may not be widely available in ACP countries. Soya flour can be added to wheat flour at a rate of 70 g per 100 kg flour. It softens the crumb and improves the appearance and colour of the crust. Lecithin is an emulsifying agent that reduces the stickiness of the dough and allows more water to be incorporated. It may be available in a pre-mix with fat and flour, which is used at a rate of 1% of the flour weight. Alternatively, lecithin can be mixed with flour at a rate of 90–180 g per 100 kg flour. Other emulsifying agents are glyceryl monostearate (used at 90 g per 100 kg flour) and stearyl tartrate (used at 45 g per 100 kg flour).

Pre-mixed ingredients (e.g. where all the dry ingredients in a recipe are rubbed into the fat in bulk) are becoming more readily available to bakers in some countries either from local suppliers or via import agents. It is also possible for bakers to make their own pre-mixes. This gives greater control over ingredient formulation, saves time during production and provides work for production staff during quieter periods. It also reduces the risk of any ingredient being forgotten in a batch of dough.

Baking bread

The basic ingredients for making bread are strong flour, yeast, water, fat and salt. In contrast to many Western countries, where bread is eaten with margarine or butter (e.g. as sandwiches with a variety of savoury or sweet fillings), bread and buns are eaten alone in many ACP countries. As a result, consumers prefer a sweeter product than European breads and adjustments to these recipes are therefore required. Sugar is routinely added to make a sweeter product and milk, milk powder or additional fat can also be added to produce a softer texture and richer flavour. White flour is most commonly used, but in some countries there is a small but growing consumer demand for wholemeal or whole-wheat breads. The traditional 'straight dough' or 'bulk fermentation' method of white bread production is described below. Other methods are described in the sources in the bibliography (Appendix III).

The manufacture of bread using the straight dough process has eight main stages:

- mixing the ingredients to form a dough
- kneading the dough to develop the gluten structure
- bulk fermentation, usually for three hours at 27°C
- dividing and moulding, to form pieces of dough of the correct size, and to reduce the size of gas bubbles
- intermediate proving step to allow the dough to relax
- knocking back and final moulding
- final prove to allow the yeast to gently inflate the dough
- baking to produce the shape and colour of the crust and to set the internal structure.

These stages are described in more detail below. The same procedures are used for bread rolls and pizza bases and formulations for different types of bread are shown in Table 4.7. Differences in the proportions of ingredients and conditions used at each stage of the process give rise to the wide variety of flavours and textures that can be produced. Even a small change in a recipe or process can produce a completely different product. It is therefore essential to record these details carefully during product development, and to ensure that exactly the same procedures are used for each batch of product. Quality assurance checks for ingredients and baked products are described in Chapter 5 (section 5.3).

Calculating the dough temperature

The temperature of the dough is one of the most important factors controlling the rate of yeast fermentation and this partly determines the amount of bread that can be produced per day. The temperature should be maintained at 25–27°C to allow the yeast to work. If it is too high (above 49°C) it will kill the yeast, and if it is too low (<20°C) the yeast will not ferment the dough quickly enough. One of the easiest ways of adjusting the dough temperature is to add water of a known temperature, 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. This method is suitable for large batches of dough that can retain their heat, but the water should be a few degrees hotter for small batches or if the weather is cold.

   Example
   The required dough temperature is 27°C and the flour is at 20°C.
   (Dough temperature × 2) – flour temperature = water temperature
   (27 × 2) – 20 = 54 – 20
   = 34°C

2. Major factor method. The simple method only takes account of the flour temperature, whereas this method also takes the temperature in the mixing room into account. To use this method, start on a day when the bread produced in your bakery is particularly good and note the temperatures of the flour, water and inside the bakery room. Add these temperatures together to get the major factor figure. This number can then be used in all subsequent production to make consistent products even if the temperatures change.

   Example

Bakery room temperature	= 22°C
Flour temperature	= 20°C
Water temperature	= 34°C
Total (major factor figure)	= 76

   If on a following day, the room temperature rises to 26°C and the flour temperature to 22°C, these temperatures are subtracted from the major factor figure to calculate the required water temperature:

Major factor figure	76
Less flour temperature	22
Less bakery temperature	26

   Therefore water temperature = 76 – 22 – 26 = 28°C

   i.e. 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.

Fermented products	Ingredients												
	Hard white flour (kg)	Whole meal flour (kg)	Soft white flour (kg)	Yeast (g)	Salt (g)	Baking powder (g)	White sugar (kg)	Water (kg)	Eggs (kg)	Milk (kg)	Butter (kg)	Baker's fat (kg)	Other ingredients or special preparation method
White bread	10			100	176		0.09	5.89				0.10	
White crusty bread	10			300	200			5.30					
Wholemeal bread		10		200	150		0.10	7.20				0.20	
Wholemeal bread (2)	5	5		151	180		0.115	6.00				0.25	
Cheese bread			10		31	62				1.24		0.48	31 g mustard, 1.0 kg cheese
Sweet bread			10	296	100	296	2.50	2.40	2.00			1.84	Lard instead of baker's fat
Rice bread						33	3.86		2.22	1.85	1.68		Cream instead of milk, 10 kg rice flour + 415 g dried cheese
Milk bread	10			300	200			5.85				0.30	0.6 kg milk powder
French bread	10			250	210			6.20					0.2 kg dough conditioner [1]
Ciabatta	10			500	200			7.10				0.50 kg olive oil	0.05 kg vinegar, 0.05 kg soya flour added to strong flour
Pizza base	10			130	180			5.26	0.13				
Crusty rolls	10			518	140		0.14	5.88				0.28	0.28 kg milk powder
Soft rolls	10			520	140		0.14	5.15	0.58			0.89	0.29 kg milk powder
White rolls	10			151	180		0.13	6.00				0.20	0.2 kg skimmed milk powder
Scotch baps	10			450	200		0.15	6.40				0.55	
Bridge rolls	10			500	200		0.15	4.45	1.40				0.3 kg milk powder +1.4 kg butter
Doughnuts	10			500	160		0.80	5.00	0.40			0.86	

[1] *Flatten dough into oval shapes, cover with plastic and prove at 27°C for 30 minutes. Mould into 70 cm long baton shape. Do not knock too much gas out of the dough. Place on trays and make series of cuts along dough surface. Cover with cloth and prove for 80-100 minutes. Steam bake at 220°C for 25 minutes.*

Table 4.7 Formulations for breads, buns, doughnuts and rolls

Mixing ingredients and kneading the dough

The basic procedure for bread-making is as follows:

1. Accurately weigh all dry ingredients into a mixing bowl
2. Dissolve the yeast in warm water (30–34°C). Dried yeast is used at 50% of the weight of fresh yeast
3. Add the yeast to other ingredients and start the mixer
4. Record the mixing time, dough and room temperature and mixer speed
5. Check the dough at intervals and continue mixing until it is soft and smooth, but not sticky.

Crusty breads are usually baked on trays rather than in baking tins. Because the dough has to support its own weight and retain its shape during baking, the dough should be firmer than tin breads. Tin breads have a softer dough because the tin supports the dough shape during baking. The dough rises more quickly during proving and baking, producing a larger loaf. Kneading involves squeezing and rubbing the dough to produce a smooth silky finish (Fig. 4.3). Machine-mixed doughs require only a short gentle kneading after mixing.

Fig. 4.3 Dough fermentation (Photo: R. Zulu)

Bulk fermentation (or first proving)

The dough is placed in a proving cabinet. The dough is allowed to rise until it has approximately doubled in size. It should then be light to the touch and smell fresh. 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.

Knocking back

When dough is first made, it is tough, but after about three quarters of the fermentation time has passed, it becomes full of gas and the gluten relaxes. The inflated dough is then 'knocked back' to its original size by kneading to expel the gas. Knocking back improves the quality of a loaf because it stretches and conditions the gluten, removes large gas holes and produces a more stable crumb structure.

Dividing and moulding (or 'scaling')

The dough is cut into pieces of uniform size and carefully weighed to ensure that each is the same weight. This can be done by hand, or using mechanical dough dividers (see section 3.3). The dough pieces are then allowed to rest for a short time. Dough loses 10% to 12.5% of its weight when water is lost during baking, and this needs to be taken into account when calculating the required weight of the pieces. The following formula can be used to calculate the weight of dough pieces:

Example: Required weight of final loaf = A (g)
Baking loss (found during product development trials) = B (%)
Weight of dough piece = $A + (A \times B)$
So, if the trials indicate a baking loss of 10%: for an 800 g loaf,
the required weight of dough = $800 + (800 \times 10\%) = 800 + 80 = 880$ g

Moulding and final prove

The dough is moulded into the required shape by hand (Fig. 4.4) or using a mechanical moulder. Shapes include cylinders for rolls, rolled out flat (or 'pinned') with a rolling pin for pizza bases or made into ropes that are then plaited (Fig. 4.5). For loaves and rolls, the 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.

Fig. 4.4 Manual dough moulding

The dough pieces are then placed into greased tins or onto greased trays and allowed to prove. The time of proving varies considerably and is judged by an experienced baker looking at both 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. It is important that the dough has a smooth and silky appearance in order to produce a good finished product. Any rough edges at this stage will make the final product less attractive. Some doughs are glazed with egg wash before baking to give a golden brown crust colour. It should be applied before both first and second provings. A little salt added to the egg improves the crust colour. Alternatively, a sugar glaze can be applied after baking to give a shiny surface to the product. This is a boiled sugar syrup which may contain a flavouring or essence (e.g. lemon, vanilla etc.). It is applied after baking while the products are still hot.

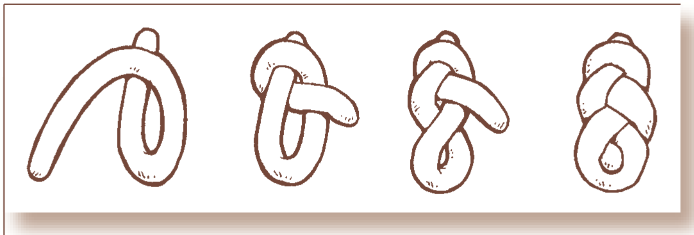


Fig. 4.5 Plaited dough

4

Baking

Any baked-on food should be removed from baking tins or trays, but it is not advisable to wash them, as this will destroy the non-stick properties that build up over time. Oil is rubbed in a thin layer or sprayed into the baking tins. When baking rolls, biscuits or other products on baking trays, it is important to ensure that there is sufficient space between the dough pieces to allow for expansion and to permit heat to penetrate the sides. The spaces between pieces should be the same to achieve uniform baking. Baking times and temperatures for different products are shown in Table 4.8. These are for guidance and actual times and temperatures depend on the particular recipe and oven that are being used. As a general rule, the richer the product (the more fat, milk, sugar etc.), the lower the baking temperature.

A simple check to determine if a loaf is adequately baked is to lightly tap the underside. A properly baked loaf has a hollow sound. After baking the products are allowed to cool to room temperature on cooling racks. Baking losses are calculated using the following formula:

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

Product	Baking temperature (°C)	Baking time [1] (min)
Puff pastry (egg washed and unfilled)	238	5–8
Plain fermented buns	238	8–10
Choux pastry (éclairs, cream buns)	232–238	20–25
Scones	232	15–18
Finger sponges	232	6–8
Plain biscuits	232	10–15
Swiss rolls	232	5–6
White bread	230	40–45
Bread rolls	230	10–12
French and Vienna breads	230	20–25
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 (small)	each 215–227	each 12–15
Buns (medium rich, e.g. Chelsea buns)	210–220	12–15
Meat pies, patties (small)	215	15–20
Short crust pastry (e.g. pastries, tarts, custard pies) Sandwich sponge cakes Rich biscuits	each 204–215	15–18 20 18–20
Light gateaux	204	12–15
Shortbread (large)	193–204	15–18
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	20–30
Rich cakes Gingerbread	160	2–3 hours 15–20
Meringues	121	10–15

[1] *Baking time depends on the size of the pieces.*

Table 4.8 Baking temperatures and times for different products

Product assessment

Details of methods for assessing the quality of baked goods are given in Chapter 5 (section 5.3). Types of faults in bread and their possible causes are shown in Table 4.9. (pp. 120–121).

Baking buns

The term 'fermented small goods' refers to a range of products including buns, plain and fancy rolls, baps and muffins. Buns may also have fruit, spices, essences, egg, milk powder, butter or fat added. Fruit is added after mixing to avoid crushing it and spoiling the appearance and colour of the product. Typically sultanas, currants, cherries or mixed fruit peel are added, but any dried fruit can be used. A small amount of flour and a little sugar (about 10%) and yeast are mixed to a thin batter. The yeast acts rapidly with vigorous gas production, leading to a frothy mass (the ferment). If left long enough the froth will collapse. Some bakers believe that the ferment must collapse before it can be made into a dough, and impatient operators may kick the fermenting tub to hasten the collapse and allow them to get on with their work. Dough ripens more quickly when a collapsed ferment is used, because the acids produced by the fermentation assist the gluten ripening. Most buns are made using the standard ferment and basic dough shown in Table 4.10.

4

Ferment	Dough
0.5 kg water	0.9 kg flour
0.05 kg yeast	0.124 kg fat
0.012 kg sugar	0.1 kg sugar
0.025 kg milk	0.1 kg egg
0.1 kg flour	salt and flavourings as required

Table 4.10 Basic recipe for a bun ferment

The ferment is added to the dough ingredients and mixed to form the final dough. This is knocked back after 30 minutes of fermentation at 27°C. The dough is then weighed (or 'scaled'), proved and baked on baking trays as described above for bread. When they are removed from the oven, buns can be washed with a glaze made from one of the following recipes:

1. Two parts fresh egg and one part water, whisked together
2. Two parts egg, one part sugar and one part water, whisked together
3. One part sugar and one part water boiled and then cooled. 1.25% powdered gelatine is added as the mixture cools.

Lemon essence may also be added to each of the above glazes.

Faults / Causes	Under-ripe dough	Over-ripe dough	Tight dough	Slack dough	Uneven oven heat	Under proven	Over proven	Over baking	Low oven temperature	High oven temperature	Too much sugar	Flour too strong	Flour too weak	Poor moulding	Lack of salt	Too much salt	High dough temperature	Damp storage	Storage too warm	Poor dough mixing	Too much fat	Too little fat	Excessive top oven heat	Wrapping before cooled
Small loaf volume	✔		✔			✔				✔			✔			✔								
Cauliflower top		✔		✔			✔					✔			✔		✔							
Flat top		✔		✔			✔		✔				✔			✔								
Pale crust		✔							✔						✔									
Overdark crust	✔									✔	✔					✔								
Holes under crust			✔																				✔	
Cracks in loaf	✔				✔	✔																	✔	
Crust breaks down/separates		✔												✔										
Wrinkled crust							✔																✔	✔
Lack of bloom		✔		✔			✔		✔						✔		✔							
Blisters on crust	✔						✔																	
Leathery crust				✔														✔						
Thick crust	✔		✔					✔		✔		✔					✔							
No oven spring		✔		✔			✔		✔				✔				✔							
Collapsed loaf		✔					✔										✔							
Long holes in crumb	✔					✔						✔												
Large holes in crumb		✔		✔		✔	✔						✔	✔			✔				✔			
Uneven crumb texture	✔	✔	✔	✔		✔	✔							✔		✔					✔			
Close crumb texture	✔		✔			✔										✔								
Crumbly crumb		✔	✔				✔	✔					✔	✔	✔		✔				✔			
Poor crumb colour		✔		✔		✔	✔						✔	✔	✔		✔							

Faults / Causes	Under-ripe dough	Over-ripe dough	Tight dough	Slack dough	Uneven oven heat	Under proven	Over proven	Over baking	Low oven temperature	High oven temperature	Too much sugar	Flour too strong	Flour too weak	Poor moulding	Lack of salt	Too much salt	High dough temperature	Damp storage	Storage too warm	Poor dough mixing	Too much fat	Too little fat	Excessive top oven heat	Wrapping before cooled
Tough crumb	✓		✓			✓		✓	✓			✓				✓						✓		
Sticky crumb		✓		✓							✓													
Soggy crumb					✓				✓											✓				
Poor flavour		✓														✓								
Sour taste		✓					✓								✓		✓							
Incorrect shape	✓	✓	✓	✓	✓	✓	✓					✓		✓			✓			✓				
Short shelf life		✓	✓			✓	✓	✓	✓			✓			✓				✓			✓		
Mould growth				✓														✓						✓
Rope									✓															

Table 4.9 Faults in bread-making (adapted from Cauvain and Young, 1998 and Flour Advisory Bureau, London)

Baking 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 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 ten minutes and then moulded into the final shape and proved at 35°C. It is then fried at 185–190°C, turning to ensure that both sides are golden brown. While still hot, doughnuts may be coated with sugar. Alternatively, when cooled, jam may be injected into the centre using a piping bag, or a slit may be cut in the side and filled with jam and/or cream.

Baking flat breads

Flat breads include fermented doughs such as *naan* and pizza bread, and unleavened breads that do not require fermentation, such as *roti, chapati* and *tortillas* (Fig. 4.6). Single-layered leavened flat breads are made in a similar way to bread dough and then rolled out flat before baking. For example, pizza dough is prepared and proved for 5–15 minutes at 35–40°C. It is then divided into balls, pressed 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, fish, chilli or red pepper) are added and it is baked at 230°C for 10–15 minutes.

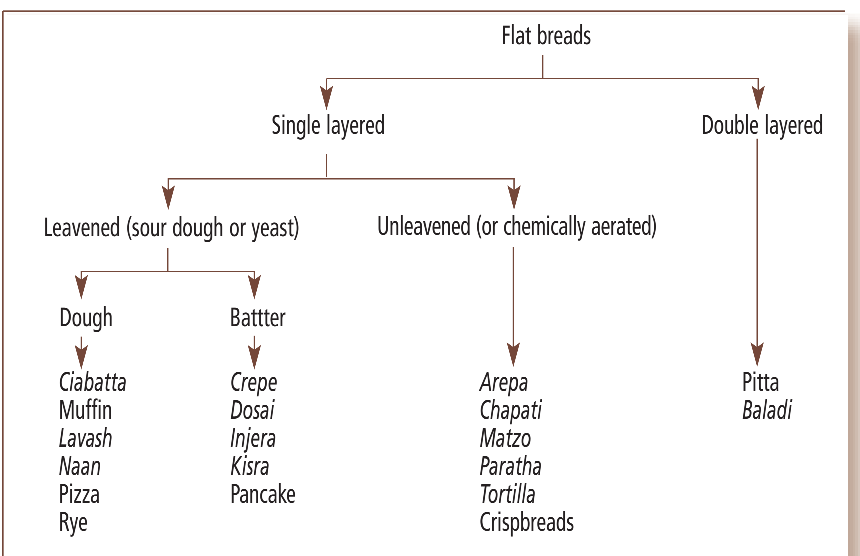


Fig. 4.6 Examples of different types of flat breads (Adapted from: Qarooni, 1996)

Double-layered breads are made in a similar way, but they are given a second proving of between five and ten 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°C) for 18–100 seconds, the skin forms a crust, and the steam inside the dough, together with carbon dioxide from the proving, force the top and bottom crusts apart creating two layers.

Unleavened flat bread doughs are prepared and then rolled thinly before baking, often on a griddle or hotplate. For example, the method for producing *tortillas* is as follows.

1. Water and half of the butter are boiled together, slowly stirring in maize meal until all is absorbed, and then adding the remaining butter and mixing to a smooth paste.
2. After cooling, salt is mixed into the flour, which is then added to the paste and kneaded to form a soft dough.
3. The dough is divided into equal pieces that are made first into round balls and then each rolled out to approximately 15 cm discs.
4. The discs are baked on a griddle for two to three minutes on each side or until the surface is flecked with brown spots. They can then be filled with a variety of savoury fillings.

Batter-based breads are made by mixing the ingredients to form a uniform batter, and then pouring a portion onto a hotplate. After a few seconds, the bread is turned over and the other side is baked. Recipes for a selection of flat breads are shown in Table 4.11.

Baking biscuits and cookies

Biscuit or cookie dough is made either by adding ingredients in turn to the flour with constant mixing, or by mixing together all the ingredients except flour and then carefully mixing in the flour until it forms a well mixed dough. 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. 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 until light brown. A selection of biscuit and cookie recipes are given in Table 4.11.

Baking pastries

Choux paste is used to make éclair type pastries that can be filled with many different types of sweet, savoury or cream fillings. Water, butter and salt are boiled together and then removed from the heat while the flour is added little by little with constant stirring. The mixture is then returned to the heat 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.

Pastry casings for pies and savoury flans are made from savoury pastes that can be 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'). The method involves mixing equal amounts of fat to flour, using the slowest mixer speed. Salt water is added to the mixture 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 for products that can be cut out or hand-raised to form a pie case. The fat and flour are mixed together at the slowest mixer speed until a crumb is formed. Boiling salt water is added to the crumb, mixing until a paste is formed. This can be used either warm or cold.
3. Boiled paste is used only for the production of hand-raised pies. The water, salt and fat are boiled together, and the flour is then added slowly with constant stirring and continued heating. It should be used while still hot.

Pies can be made by simply folding a square of pastry corner-to-corner to form a triangular shape, with the filling contained inside by pressing the moistened edges together. Alternatively, a pie casing can be used to form the shape of the pie. If meat, fish or vegetables are used as fillings, these should be thoroughly cooked and used immediately to avoid the risk of micro-organisms growing. Meat and fish in particular should be carefully selected and processed under hygienic conditions that are strictly enforced. Further details are given in *Setting up and running a small meat or fish processing enterprise*, another CTA publication in this series.

Short (or shortcrust) pastry is used to make a very wide range of flan casings and tarts (see Table 4.12, page 133). The word 'short' means that the pastry is easily broken and should not be at all leathery or tough. It can be kept, uncooked and properly wrapped to prevent it drying out, in a refrigerator for a few days, or up to two weeks when baked. Pastry is made using the sugar/batter or the flour/batter method, described for cakes below. Castor sugar should be dissolved in the liquid or creamed with the fat, but granulated sugar should be avoided because it forms dark spots on the surface during baking, spoiling the final appearance. It is important to keep ingredients cool at all times, using a refrigerator if necessary, and not to over-mix, as the pastry becomes sticky. The pastry is used to line a flan dish or a baking tray with a flan ring placed on it, and then baked until golden brown. Fig 4.7 illustrates a wide range of baked pastry products.

Fig. 4.7 A range of pastry products

Products	Hard white flour (kg)	Soft white flour (kg)	Yeast (g)	Salt (g)	Baking powder (g)	Sugar (kg)	Water (kg)	Eggs (kg)	Milk (kg)	Butter (kg)	Baker's fat/ margarine (kg)	Other ingredients
Cashew biscuit		10				5.00		1.00			0.89	0.446 kg finely ground cashew nuts
Coconut biscuit		10			300	4.40		3.10			3.10	1.20 kg desiccated coconut
Plain biscuit		10			20	4.00		1.33			4.00	Essences, nuts, dried fruit can be added as required
Groundnut biscuit		10			100	6.00		1.00			6.00	Press dough into crushed groundnuts before baking
Lavash	10		100	200			5.00					0.025 kg soda
Tortilla				280			1.94			2.28		10 kg maize meal
Chapati	10			opt			5.00			opt		
Pitta	10		75	112			5.50					
Naan	10		400	100	100			0.90	3.0			1.0 kg vegetable oil + 3.0 kg plain yoghurt
Pancake	10			140	250	2.33	7.73	3.87		1.90		1 kg skim milk powder, 12 g vanilla
Roti	10			pinch			6.40					7.5 kg *chapati* flour mixed with wheat flour, 0.42 kg oil instead of fat, ghee brushed onto bread [1]
Rye bread	5		25	30			0.665				0.015	5 kg rye flour added to strong flour, 15 g black treacle + 25 g caraway seeds

[1] *Prove dough for 15–20 minutes, roll each piece to a cylinder shape and divide into eight pieces. Roll each piece into balls, cover and rest for 5 minutes. Roll balls out to 20 cm discs. Using moderate griddle, cook each side for 45 seconds until brown flecks appear, brush both sides with ghee. Place roti between two wire racks and hold above high heat for 15 seconds to puff.*

Table 4.11 Formulations for selected biscuits and flat breads

Tart pastry is made by mixing flour and salt, lightly rubbing in fat, and then slowly mixing water into the flour to make a stiff paste. The pastry should not be rubbed too much, as this gives a greasy product, and it should only be rolled out once to prevent toughening. Care is also needed to avoid adding too much liquid and producing a wet paste. Flan pastry is made by sieving the flour and baking powder together, adding margarine, and mixing at a slow speed to form a crumb. Then egg and sugar are mixed together until all the sugar is dissolved, and this is added to the crumb and mixed to a lump-free paste, if necessary adding lemon juice as it forms. Recipes for tart and flan pastry are given in Table 4.15. The pastry is carefully rolled to 0.5 cm thick and placed on a greased baking tray with a flan ring on it, or in a greased flan dish. A circular piece of greaseproof paper is placed on the pastry and weighed down with baking beans or a similar alternative. It is baked at 215°C until golden brown, then filled with a sweet or savoury filling.

Puff pastry is made by gradually mixing flour with beaten egg and adding sufficient water to make a stiff paste. This is rolled out thinly and small pieces of butter or margarine are laid on top of the paste. They are covered with the remaining flour, the sheet is rolled into a tight tube and then 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. It is refrigerated for one to two hours and then formed into slices or 'horns', or other shapes than can be filled with cream or sweet or savoury fillings (e.g. vol-au-vents). Puff pastry should be baked at 261–275°C until golden brown.

Baking cakes and scones

Products such as cakes, scones and soda bread are known as chemically raised doughs because they rely on gas produced from baking powder to raise the dough and produce the desired crumb texture. There are two main methods of making cakes: the 'sugar-batter' method and the 'flour-batter' method.

Sugar-batter method

Fat, margarine or butter is beaten with sugar to create a cream. Any colouring or essences should be added at this stage. Then egg is mixed into the cream. If a mixer is used, the egg can be added in a steady stream, whereas if mixing is done by hand, the egg is added in four portions, beating each one into the mixture in turn. The sieved flour and baking powder are then carefully added and folded into the batter. The aim is to achieve a smooth, lump-free batter but without toughening it by too much mixing. Other ingredients (fruit, milk, nuts etc.) are carefully blended into the batter and the whole is poured into a greased baking tin and baked at 182°C until cooked through.

Flour-batter method

Sugar and egg are whisked together to form a batter. The flour is sieved to incorporate air, then carefully folded into the egg/sugar mixture, causing as little disturbance as possible to its light structure, until the batter is smooth and free from lumps. Any remaining liquid and any fruits, nuts or other ingredients are then carefully blended into the batter. 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 four equal portions, beating each portion together. It is important to keep the two mixtures at the same temperature. The batter is then placed into a greased baking tin and baked at 204°C until the interior is properly baked.

Correctly balancing ingredients

The basic ingredients in a cake each have particular functions:

- those that provide strength and structure to the cake (flour, egg)
- those that open the texture (sugar, fat, baking powder)
- those that close the texture and reduce lightness (milk, water).

Every cake recipe should have a correct balance of these ingredients. There are hundreds of different recipes for cakes, and a summary of recipes for a small selection of products is shown in Table 4.12. However, each complies with three basic rules for cake-making:

- the weight of fat should not exceed the weight of egg
- the weight of fat should not exceed the weight of sugar
- the weight of sugar should not exceed the weight of total liquid.

Based on the weight of flour as 100, a balanced recipe for a plain cake of reasonable quality contains:

• fat: between 20 and 60
• sugar: between 50 and 60
• total liquid: between 80 and 90.

Note: the amount of fat must be balanced with the amount of egg and flour. A general rule is to keep the weight of egg equal to the weight of fat or slightly in excess.

A high sugar cake could contain:

• Flour: 100
• Fat: 30–60
• Sugar: 100
• Liquid: 100–110.

The effect of too much or too little of each ingredient is shown in Table 4.13 and Fig. 4.8. Table 4.14 shows the ratio of fruit to batter in different types of fruit cakes.

Ingredient	Purpose	Effect of too much	Effect of too little
Sugar	Sweetens cake and lightens the texture. Helps form the crust, develops the colour, improves the flavour of other ingredients and preserves the cake.	Causes batter to over-expand and structure to collapse. The crust has brown sugar spots and the crumb is open and sticky.	Produces smaller cake volume and a 'pecked' crown. Crust has a lack of bloom and crumb is too closely formed because the gluten is insufficiently softened.
Fat	Opens the texture, improves the eating quality and carries flavours.	Small cake volume, a thick and greasy crust, a crumb that is greasy and collapsed at the base.	Poor crust colour, smaller volume and the crumb has tunnel holes pointing to the centre of a peaked top. The cake is tough and will stale rapidly [1].
Milk	Moistens the cake and reduces lightness.	Tough, rubbery texture. The cake collapses as it cools. A heavy solid core forms at the base with a large hole above it [2].	The cake lacks volume, tastes dry and stales rapidly.
Egg	Gives structure to the crumb.	Tough, rubbery crumb.	Not essential – no major effect
Baking powder	Produces carbon dioxide which raises and aerates the batter, to give honeycomb texture in the cake.	Produces too much gas, which expands the cake more than the gluten can stretch causing the cake to collapse during baking. The crust is darker and the crumb is open textured and discoloured near the base.	Loss of volume (also due to old or badly stored baking powder).

[1] *This is because the effect of the fat on the gluten is reduced 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.*

Table 4.13 Effect of ingredients on cake quality

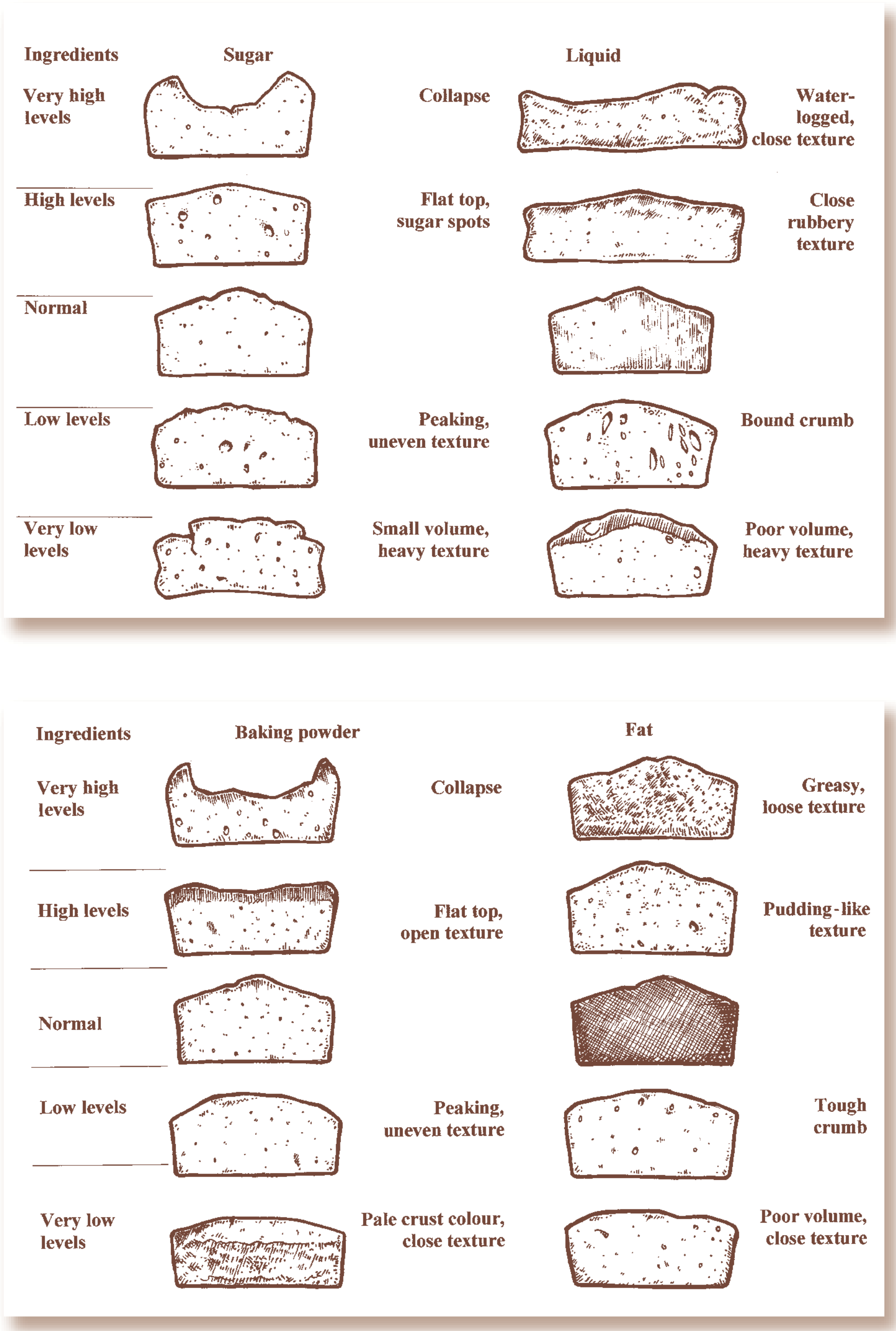


Fig. 4.8 Cake faults

Type of cake	Fruit (%)	Batter (%)
Birthday cake	50	50
Christmas cake	45	55
Fruit cake	20	80
Wedding cake	55	45

Table 4.14 Proportions of fruit and batter in different types of fruit cake

4

Decorative icings

Fig. 4.9 Cake decoration

Among more wealthy sections of society in ACP countries, celebration cakes for birthdays, weddings, graduation ceremonies etc. are status symbols that are highly valued (Fig. 4.9). When made to a high standard with attractive individual designs and decoration, they can be sold for several hundred dollars in some countries and thus offer very good opportunities to bakers to increase profitability. Production of attractive decoration and unique designs are skills that bakers can acquire after they have mastered the techniques for producing marzipan, icing and gum tragacanth figures. A detailed description of the opportunities in this area is beyond the scope of this book. Bakers who wish to develop artistic skills in this area should consult the relevant texts in the bibliography.

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 to the crumb, mixing carefully to form a smooth dough. If required, fruit is then added carefully so that the dough is not toughened. The dough is dusted with flour, rolled out to the required thickness (e.g. 1 cm), and cut into round shapes of the required size using a biscuit cutter. These are baked on a griddle (or hot-plate) until browned on each side. Scones can also be oven-baked.

Packaging and storing baked goods

In general, baked goods have a short shelf life and do not require sophisticated packaging. Bread is usually eaten within one or two days and simple paper or polythene bags are conveniently used to keep the bread clean or to hold sliced bread together.

> *If polythene is used, the bread should be packed after it has cooled to prevent condensation inside the pack resulting in wet spots, which would cause mould growth.*

Bags can be sealed using a heat sealer, a knot or a plastic or metal tie. Products such as biscuits have an extended shelf life (from a few weeks to several months) and require packaging that prevents moisture pickup from the surrounding air. Biscuits that contain fat should be protected from light, air and heat to prevent development of off-flavours due to rancidity. They may require additional protection against crushing or attack by insects, birds etc. Some types of plastic films (polypropylene, polyester, but not polythene), paperboard cartons covered with film, glass jars or metal tins are all suitable packaging materials. Further details of packaging requirements and materials are given in texts on packaging in the bibliography.

The packaging and storage requirements for cakes depend on their moisture content and the humidity of the surrounding air. Each type of cake must be judged by its composition and the intended shelf life. Light cakes (i.e. those made from flour, sugar and egg) have a shelf life of only a few days if not packaged. Fruit cakes have a longer shelf life, which can be extended to several months by coating in marzipan and icing sugar, both of which act as a moisture barrier. Cakes can be packed in moisture-proof films or tins.

Products	Soft white flour (kg)	Dried yeast flour (kg)	Salt (g)	Baking powder (g)	Sugar (kg)	Water (L)	Eggs (kg)	Milk (L)	Butter (kg)	Baker's fat (kg)	Other ingredients or special preparation method
Plain cake	10			770	10.00		12.50	2.20	7.50	2.50	Essences and colouring to taste
Banana cake	10			150	6.25	5.00	2.40			5.00	7.4 kg mashed banana
Spiced fruit cake	10		155	625	5.00		2.40	6.20		5.00	310 g mixed spice + 150 g cinnamon + 5 kg sultanas + 240 g chopped nuts + 120 g chopped peel + 240 g glacé cherries
Cup cake	10		138	415	5.54		4.46	4.20		4.46	138 g vanilla essence
Chocolate cake	10			500	6.13		3.87	7.10		6.13	1.936 kg cocoa powder
Coffee cake	10			625	3.80		2.40	5.00		5.00	Use brown sugar; 1.25 kg coffee essence + 1.20 kg cocoa
Nut cake	10			150	5.00		5.00	2.40		5.00	150 g mixed spice + 150 g cinnamon + 150 g ground ginger + 2.4 kg finely chopped nuts
Sponge cake	10				10.00		1.18				Use castor sugar
Ginger sponge	10			186	10.00		4.00				100 g arrowroot +125 g cocoa powder +252 g ground ginger + 125 g cinnamon + 50 g golden syrup
Puff pastry	10					5.30			10.00		Medium strength flour + 150 g lemon juice
Cold water paste	10		150			2.65				4.45	Lard
Hot water/boiled paste	10		150			2.50				5.00	Lard
Shortcrust pastry	10		35		1.14	0.89			5.29		Egg colour if required
Sweet pastry 1	10					0.10	1.25	1.25		2.50	
Sweet pastry 2	10					0.10	2.50		1.95	6.25	0.55 kg lemon juice
Sweet pastry 3	10						3.90		1.40	5.55	
Tart pastry	10				pinch		0.04				
Flan pastry	10					0.10	2.50		1.95	6.25	0.5 kg lemon juice or to taste
Scones	10			472	1.70		1.25	5.00		2.80	A few drops of egg colour and oil of lemon
Currant scones	10		80	619	1.25		1.25	5.40		1.25	1.87 kg currants

Table 4.12 Formulations for cakes, pastries and scones

Summary of the chapter

✔ Be innovative and develop new products to stay ahead of the competition

✔ Get bakery books and try out new recipes

✔ Make careful measurements of ingredients and processing conditions when developing new products

✔ Use the production methods described for flours, composite flours, weaning foods, breads, biscuits, cakes, pastries, flans and pies to make high quality products

✔ Seek advice if you are planning to make weaning foods

✔ Ensure that suppliers of raw materials and ingredients are satisfactory. If not, change to another supplier

✔ Evaluate your products objectively before putting them on the market

✔ Pay attention to the design and presentation of bakery products – an attractive appearance can increase sales

Entrepreneur's checklist

❑ Have you checked with customers what types of products they might buy?

❑ Do you know where to get information on product recipes?

❑ Do you know how to make a new product by producing test batches?

❑ Are you satisfied with suppliers of raw materials, ingredients and packaging materials? If not, what steps will you take to change the situation?

❑ Do you need further training to be able to make a satisfactory product? Who can train you?

❑ Do you know how to assess your products objectively?

❑ Are you aware of current trends in the milling and baking industry?

❑ Can your equipment handle the products you want to make?

Readers' notes

Please use this space to make your own notes on Chapter 4.

Quality assurance and legislation 5

5.1 What is quality assurance?

Product quality is one of the main features that customers look for. Products must be safe to eat and must also meet consumers' ideas of good quality and value for money. Producers should find out what their consumers think by conducting a market survey (see Chapter 2). There are other aspects of quality to consider: regulatory quality concerns the laws that relate to the quality of foods in general, and there are specific laws for individual products. General food laws are described in Volume 1: *Setting up and running a small food business*, and specific laws for flours and bakery products are described below. Both the consumers' view of quality and the legal aspects of quality require that products are made to a consistent standard in every batch. People expect the quality of their food to be the same time after time.

To achieve this it is necessary to have a quality assurance (QA) system. Many small-scale millers and bakers do not have such a system in place; instead problems are simply resolved as they arise. This approach does not ensure consistent product quality. Any failures in processing may pass unnoticed and lead to faults in the product.

Tips for success

Product quality

✔ Quality can only be achieved and maintained through hard work and commitment

✔ Ask yourself, is this product good enough; is it presentable?

✔ Maintain your standards of quality, no matter what happens, because once customers are lost, they cannot be recovered

✔ Consistency is the key to good product quality

✔ Do not compromise on the quality of raw materials or recipes

Staff

✔ Good standards of hygiene should be maintained. Although your customers do not supervise production, they should be confident that your products are produced properly

✔ Personal hygiene should not be compromised

✔ Ask for help if you are not sure how to implement quality control

✔ **Finally:** Read sections 6.1–6.6 and 10.2 in Volume 1: *Setting up and running a small food business.*

It is much better to identify where problems may occur and have a plan to prevent them before they arise, rather than trying to correct them afterwards. Not only will this ensure a uniform quality product, but the producer will also save money and the image and reputation of the company will be protected.

This chapter describes the steps needed to set up a QA programme in a mill or bakery.

5.2 Milling

A successful milling business will produce flour of consistently high quality. Customers judge the quality of the flour they buy based on three factors:
- purity and lack of contaminants
- fineness
- correct weight in the pack.

Commercial customers, such as bakers, also judge the quality of wheat flour by its gluten content (see section 4.3).

Preventing contamination is the most important aspect of QA for most small-scale millers. The main contaminants found in grain are:
- foreign material (soil, weed seeds, stones, string, leaves etc.)
- infestation by insects, excreta, hair from rodents or feathers from birds
- mould growth
- chemical residues
- oil or grease from vehicles or machinery.

A well designed QA programme prevents these contaminants from entering the factory or discovers and removes them before they can be incorporated into the flour. The miller should also check for physical damage to grains and for immature grains.

In addition to checking the quality of incoming grains, the QA programme should also cover the following aspects of production:
- the correct operation of seed cleaners, hullers and mills
- the condition of the building
- routine cleaning programmes
- flour quality and fill weights
- correct sealing of bags and sacks.

Each of these areas is summarised in Table 5.1 and described in more detail below.

Processing stage	Activity by miller	Control points [1]
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 [2]	Maturity at harvest, drying to correct moisture content, type and condition of storage structures, prevention of insect/rodent attack
Reception and storage at the mill	Weighing incoming grain, inspection and quality checks, supervision of grain storage	Weight 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
Hulling	Operation of huller(s)	Huller 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, routine cleaning schedules
Flour storage	Supervision of flour storage	Condition of storeroom, prevention of insect/rodent attack, routine cleaning schedules
Packing	Packing flour into bags or sacks	Correct fill weights, adequate sealing of bags/sacks

[1] *Details of control points are given in Volume 1, section 10.2.*
[2] *Contract farming is described in Chapter 6, section 6.3.*

Table 5.1 QA control points for flour milling

Quality of raw materials

Poor quality grain is one of the most common problems facing millers. The reasons for this include inadequate control by farmers over conditions during harvest, drying, post-harvest storage and transport to the mill, and poor storage conditions in the mill. Most small-scale flour millers buy their grain from farmers or local market traders, and therefore have little control over the way in which the grain is grown, harvested, stored or transported. Contract agreements with farmers can improve the amount of control that millers have over their raw materials. This section describes the quality checks that can be made on grain bought from markets or farmers, followed by a summary of the methods that can be used if a miller has greater control over post-harvest handling and storage of the crop.

Crops bought from markets or farmers

Grains are usually bought in 50 or 100 kg sacks made from hessian, jute or woven polypropylene. The amount of protection offered by these packaging materials is limited and the first check should ensure that there are no holes in the sacks or loose sewing at the top. The presence of holes in a sack indicates that rats or birds could have contaminated or damaged the grain. Secondly, the sacks should be dry and clean, with no obvious contamination by oil, grease, kerosene etc. during transport.

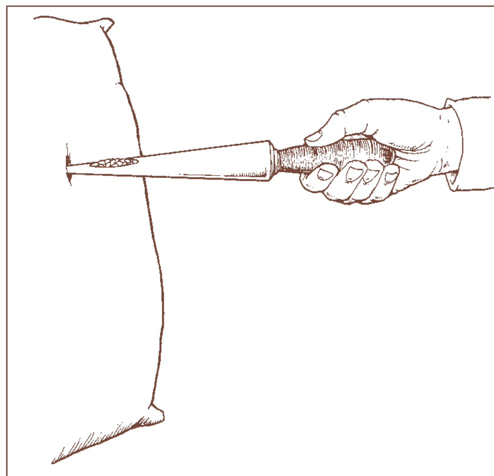


Fig. 5.1 Sampling probe for grain

If possible a sample of grain should be taken to check the quality. A sampling probe (Fig. 5.1) is a convenient tool, although one that is not commonly used in ACP countries. The sample can be checked visually for:

- contamination by foreign materials, insects, birds and rodents
- excessive moisture content or mould growth
- broken or immature grains.

Grain may be contaminated by weed seeds, stalks, soil, stones, dead or living insects and it may also be contaminated during transport by metal or wood fragments, diesel, oil, grease etc. When the sacks are opened at the mill, the grain should be spread onto an inspection table and any foreign materials, mouldy or discoloured grains removed. A sorting table can be constructed from metal or plastic mesh. A large mesh size retains large contaminants, but allows grain to fall through into a collection tank under the table. A fan placed beneath the table can be used to blow air through the falling grain to remove dust, animal excreta etc. (i.e. winnowing the grain). Alternatively, a small mesh retains the grain but allows weed seeds, dust, small stones etc. to fall through. After this preliminary cleaning and sorting, some millers wash the grain in a trough or tank to remove sand, small stones and dust. A periodic QA check can be done at this stage to collect and weigh the contaminants that are separated from the grain. The weight can be expressed as a percentage of the batch weight using the calculation:

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

The weight and type of contaminants in grain supplied by different traders or farmers can be recorded over a period of time to see whether some suppliers have consistently lower quality than others. The evidence from these checks can be used to negotiate with each supplier, either to reduce the price or to improve the quality of future deliveries. Where there is a choice of suppliers, the miller may want to use this evidence as a reason for changing to a new supplier. If suppliers know that such checks are being made, it may encourage them to improve their handling and storage procedures, particularly if the miller is willing to offer a premium price for higher quality grain.

Removal of contaminants is essential if high quality flour is to be produced and the mill is to be protected from damage. Several small-scale millers who assisted in preparation of this book indicated that the main cause of damage to their equipment, and hence additional operating costs for repairs, was failure to protect machines against stones in the grain. Others noted that high quality products that had no contaminants attracted customers, and this enabled them to develop their company's reputation and expand their market share.

The second QA check should measure the moisture content of the grain. The correct moisture contents for safe storage of grains are shown in Table 5.2.

Cereal	Moisture content (%)
Maize (shelled)	13.5
Maize flour	11.5
Millet	16.0
Rice	15.0
Rice flour	13.0
Sorghum	13.5
Soyabean flour	13.0
Wheat	13.5
Wheat flour	12.0

Table 5.2 Moisture contents of cereals for safe storage

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 but more time consuming method is to dry a weighed sample of grain in an oven at 100°C for five hours (or 104°C for two hours), cool and re-weigh it. The weight loss is calculated as moisture content using the following formula:

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

An electronic moisture analyser (Fig. 5.2) is more rapid than oven drying, but is also more expensive.

The third QA check investigates inadequate storage, immature grains or mixed varieties. Repeated changes in temperature and humidity during storage cause the grains to crack and adversely affect their milling quality. In rice, for example, this results in excessive breakage during hulling and lowers the yield, a fact that can significantly affect the profitability of the milling operation. Mould growth and dark discoloration on the grain can be caused by inadequate drying or failure to maintain dry storage conditions. These are not removed by milling and lead to a reduction in the product quality and the price that can be achieved.

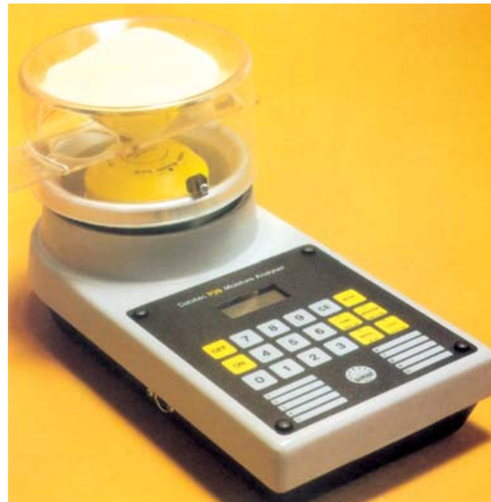


Fig. 5.2 Moisture analyser
(Photo: courtesy of Sinar Technology)

Immature grain has a higher proportion of hulls, and consequently a lower yield of flour. The limited adjustability of hulling and milling machines means that smaller grains require special measures to separate or reprocess them, disrupting the smooth operation of a flour mill. This results in lower hulling efficiency, increased re-circulation of unhulled grain and problems with grading hulled grains. Similarly, if different varieties of grain with different sized seeds are mixed together, milling capacity will be reduced, there will be a higher incidence of breakage, yields will be lower and the end product will be of poorer quality. Each of these factors leads to a reduction in the profitability of the mill.

> *If grain is bought on the open market from traders or farmers, millers have little control over quality issues and can only negotiate over the price they are willing to pay. Contract arrangements with farmers allow greater control by millers over the quality of their raw material.*

Contract grown crops

Contract growing is described in Chapter 6 (section 6.3). It gives a miller more control over the production of the grain, and can ensure a higher and more consistent quality. QA checks (in addition to the ones described above) can be used to ensure:

• correct application of chemicals during cultivation
• harvest at the correct stage of maturity
• satisfactory threshing and winnowing
• adequate drying and post-harvest storage
• proper packaging and transport of grains.

Use of pesticides or chemical fertilisers can lead to substandard quality grains or potential safety hazards. This is most likely where farmers have inadequate knowledge of, or training in, the correct quantities and timing of chemical applications. If millers provide support to farmers as part of contract agreements, they can prevent such problems by supervising chemical use and conducting checks to ensure that chemical applications are in line with manufacturers' recommendations. The use of agricultural chemicals and the presence of residual chemicals in grain are controlled by law in some ACP countries, and millers should check with the Ministry of Agriculture and the Bureau of Standards for details of the specific laws in their country.

As part of a contract arrangement, a miller can also specify and/or supervise harvesting at the correct stage of maturity, and control on-farm threshing and winnowing to reduce the level of contamination. It is not unknown for farmers to mix inedible and sometimes poisonous seeds with grains to increase their weight. These can be detected at the inspection stage in the mill, but it is obviously better if supervised contract farming reduces the chance of these being added in the first place. Harvesting at the correct stage of maturity is essential for high quality grain. Some farmers harvest grain too early because they need to generate an income from their crop as soon as possible, or they fear theft from the fields. However, immature grain has a higher moisture content and contains more active enzymes, which shorten the storage life of the grain. Immature grain also has poorer milling qualities and produces substandard flour. Conversely, if grain is left in the field for too long after it has matured, it may be repeatedly wetted with dew or rain, and dried each day in the sun. This causes the grain to crack, increasing the risk of infestation by insects and mould.

Storing inadequately dried grains leads to a significant risk of mould growth, particularly in crops such as maize that are not shelled before drying.
In maize, the mould grows out of sight, and even a small amount of infected

grain can spoil a whole store. Moulds give an unpleasant smell to flour, making it unacceptable to consumers, and some moulds are harmful to human health. Certain species produce a range of poisons, known as aflatoxins in cereals (see Appendix I). Aflatoxins have no taste and may be eaten, resulting in long-term damage to the liver, digestive system and kidneys. In one African study [1], 77% of maize contained aflatoxins, with some samples containing levels nearly three times the FDA [2] recommended maximum. Recommended storage practices for grain are as follows.

1. Make sure the storeroom or silo 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 (e.g. brick, mud, clay or wood), 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. Make sure that storerooms or silos have been thoroughly cleaned, and all old grain, straw, insects etc. have been removed and burned to prevent them re-contaminating new grain
5. Make sure that grain is properly dried before putting it into a store
6. Traditional insecticides (e.g. wood ash or neem leaves) can be used. If chemical insecticides or fungicides are used, ensure that manufacturer's recommended application dosages are carefully followed
7. Regularly check the grain for infestation, signs of mould or discoloration, 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.

Compared with many other foods, flour is relatively safe from causing food poisoning because of its low moisture content. However, grain is not heat-treated during milling and any moulds that are present are likely to be transferred to the flour. Similarly, any aflatoxin contamination will be transferred to bakery products because the poisons are not destroyed by heat.

> *It is therefore essential that good hygienic practices be observed during harvest and storage of grains and throughout the milling process, especially during stages when the grain is moist.*

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[1] *Kaaya and Muduuli (1992).*

[2] *Food and Drug Administration (of the USA).*

The embryo in cereal grains (see Fig. 3.5 on page 60) has a high oil content (18–25%) and its incorporation in milled flour reduces the shelf life because of more rapid development of rancidity, compared with flours that have a lower extraction rate (see Chapter 4, section 4.3).

Hauliers in ACP countries do not specialise in food distribution, and have little knowledge of food safety or the requirement to protect food against damage or contamination. Although most grain is loaded into sacks for ease of handling during transport, the quality of re-used sacks is often not checked. They may also be inadequately sewn up on the farm. Dirty sacks contaminate grain, and inadequately sealed sacks allow access to birds, insects and rodents, especially if the sacks are left on the farm for a few days awaiting collection. Control over packaging is part of a QA scheme, and it is preferable for millers to supply good quality sacks for collecting contracted grain, and possibly employing a member of staff to weigh and seal sacks on the farm at the time of collection.

Grains are often transported with other non-food goods that may cause contamination by oils, metal fragments, other chemicals or wood splinters. Grain can also easily absorb odours from kerosene or diesel fuel, and care should be taken to ensure that these materials do not come into contact with the grain. Transport operators are paid by the weight or volume of goods moved, and do not suffer financially if the quality or safety of the grain is compromised. However, the power of traders and middlemen makes it difficult for millers to introduce changes. A better option is for millers to collect sacks of grain directly from the farmers using their own vehicles, or use contracted hauliers' vehicles that have been inspected to ensure that they are clean (Case study 5.1).

Case study 5.1 Maize suppliers

'Our only raw material is maize, but the quality is not always consistent. We do a check on receipt of raw materials and have a set standard. We select the supplier depending on the quality received. The biggest problem is not with the packaging itself, but with the damage that occurs during transportation. We are planning to invest in a pickup truck, as I know that when we have our own transport this problem will improve. We will be able to pack the maize properly and transport it by the smoothest means. It is very difficult to dictate to a hired driver how to drive and which roads to take, as they always want to use the quickest routes, which are normally very bumpy roads.'

Quality checks on milled 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 itself. The main QA check 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

Dust is a serious problem in flour mills. Accumulation of flour dust attracts insects and rodents, which in turn contaminate the products. It is therefore essential that the mill building is correctly constructed (Chapter 3, section 3.2), and that routine monthly inspections are made to ensure that floors and walls have not developed cracks, and 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. A supervisor or mill owner/manager should ensure that the checks are done properly.

5

All spilled grain and flour dust 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. A comment from a less professional miller that: 'It is a flour mill – you expect to see flour beetles!' is not acceptable, and customers now demand higher quality products. If infestation is found it should be treated by spot-spraying, but the best approach is to prevent infestation from occurring by proper cleaning. Care should be taken to ensure that recesses behind machines, ledges and window sills are also properly cleaned. Using brightly coloured brooms, brushes and cleaning cloths ensures that bristles or cloth fragments can be seen and removed easily, thereby preventing contamination of the flour. In larger mills it may be appropriate to use different colours at each stage of the process to allow more accurate identification of any source of contamination. In previous years some millers fumigated their stores or mills once a year with methyl bromide gas. Although this is effective against all types of insects, it is also a chemical that destroys the ozone layer in the atmosphere, and since 2000 it is being phased out under the International Montreal Protocol. Fumigants and sprays that are approved in some countries to disinfest silos and grain stores include lindane, bromophos, malathion, dichlorvos, piperonyl butoxide, pyrethrum or combinations of these. Particular attention must be paid to the manufacturer's instructions, which must be explained to workers and strictly observed.

Process control

Correct operation of seed cleaners, hullers and mills is necessary to produce high quality flour at the expected feed-rate, and machines should be checked daily to ensure that settings are correct and that there are no loose nuts or bolts. Parts that are likely to wear out should be checked monthly as part of a planned maintenance programme (Chapter 6, section 6.3). Metal fragments, pieces of hardened flour, wire or nylon from sieves or cotton fibres from sacks can all contaminate flour during milling. Sieves should be used at points throughout the process to collect larger contaminants. The sieves should be checked regularly as any sudden change in the level of contamination indicates that a problem has arisen. It should be investigated and corrective action should be taken. It must never be assumed that ‘the sieves are doing their job by catching contaminants, so there is no need to worry’. The sieves are there to indicate problems and anything unusual should be investigated.

Magnets should be used to protect machinery from metal in the grain and also to remove any iron and steel fragments from the flour before it is packed. Permanent magnets are the preferred option, because electromagnets can drop a mass of filings into the flour if the power fails. Magnets indicate a problem and should be checked regularly. They are not a safety net to be relied upon and forgotten about. Magnets cannot pick up brass, copper or other non-ferrous metals.

Flour quality, packaging and fill weights

Tests for flour quality, as used by bakers, are described in section 5.3, but these are rarely performed by millers in ACP countries. However, millers could use the simpler tests as part of their marketing strategy to demonstrate the high quality of their flour.

The weight of flour in a sack or bag is controlled by law in most countries 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 (Fig. 3.13 on page 66). Stored flour should be sold using the 'first in first out' (FIFO) system.

5.3 Baking

The main reasons for low quality baked products are faults with the processing room, the process, ingredients, operators or distribution methods.
A QA programme should therefore comprise:
- ingredient inspection
- process control
- operator training
- assessing products
- cleaning schedules
- control over packaging and distribution.

Baked products are rarely involved in food poisoning incidents because the heat of the baking process kills most micro-organisms or reduces their numbers to safe levels. However, products containing meat, fish or vegetables have a greater risk of causing food poisoning if they are not handled and stored correctly. The time that these products spend in the temperature danger zone (10–45°C) during processing must be minimised by efficient handling and effective cooling. Refrigerators for cakes with cream fillings and other cream goods must be properly maintained and operated at the correct temperature. Pies and *samosas* should be either chilled in a refrigerator or stored in a hot display cabinet (above 63°C).

> *Obtaining high quality ingredients, handling food safely, proper temperature control and thorough cleaning are therefore essential if these products are to be produced safely.*

Ingredient inspection

In most ACP countries, small bakers either buy flour directly from a local miller or buy imported flour from an agent. Other ingredients, such as special fats, sugar, salt, essences and yeast are purchased from wholesalers, retailers or directly from import agents. Bakers have little control over the quality of ingredients and it is therefore necessary to conduct checks to ensure they are of a suitable quality (Case study 5.2).

The following tests are suitable for small-scale bakers because they:
- are relatively simple to use
- are sufficiently accurate for quality control purposes
- do not require sophisticated or expensive equipment
- do not require a high level of skill
- are relatively inexpensive.

Case study 5.2 Ingredient testing

In Zambia, Mrs B. said: 'We have to produce consistent quality products and we prefer not to change our ingredient measurements all the time. But the taste and texture of our products are quite sensitive to changes in ingredients. If the raw materials are not up to a certain standard then there is no guarantee that our recipes will produce the required quality, so we always check the ingredients.'

Flour

If bakers leave sacks of flour on the floor of a storeroom or in a corner of the bakery, the flour is likely to absorb moisture, leading to growth of mould, development of rancidity and attack by insects, birds and rodents.
Bakery storerooms should therefore 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 (Fig. 5.3)
- use stock rotation (FIFO)
- ensure that the store is dark and cool without temperature fluctuations

- ensure that the room is sealed against insects, birds and rodents and that doors are not left open when not in use
- clean the store each week to prevent dust accumulating
- place an insect electrocutor in the store if you can afford it (see Fig. 3.1 on page 52).

Fig. 5.3 Correct storage of flour
(Photo: R. Musoke)

Before use, flour should be checked for visible signs of mould and for a mouldy or rancid smell. Small-scale bakers can check the quality of flour and the information supplied by the miller using the following tests:
- flour infestation
- moisture content
- water absorption
- gluten measurement
- starch gelatinisation.

Evidence from testing may be used to re-negotiate prices with a miller if the quality is not satisfactory.

Flour infestation

Test for the presence of flour mites as follows.
1. Place about 100 g of flour onto a flat surface and use a ruler to spread it out and flatten it.
2. Examine the flour for evidence of pimpling (disturbance of the surface) after about two minutes. Pimpling indicates the presence of live flour mites breaking the surface for air.

The 'filth' test detects dead flour mites, insect parts, rodent hairs or faeces in flour.
1. Mix a sample of flour with petrol in a glass jar and stir thoroughly.
2. When the suspension of particles settles, the contaminants may be seen floating on the surface of the petrol. If required they may be filtered out and identified.

The sieving test can be used to detect contamination with stalks, stones, string, cigarette ends, leaves etc. as well as measuring the degree of fineness of the flour. However, the cost of specialist sieves is relatively high and the investment can only be justified if there are recurring problems with suppliers.

1. Sieve 500 g of flour through a stack of analytical metal sieves, with the largest mesh size at the top of the stack and the smallest at the base. Typically the range of sieve sizes is 1.6 mm to 0.038 mm. A mechanical shaker can be used to ensure a consistent amount of shaking, but this adds further to the cost.
2. Weigh the material that is collected on each sieve and express it as a percentage of the total weight. Contaminants are retained on the larger sieves and can be examined if necessary.

Moisture content

Testing for moisture content requires accurate scales (measuring to three decimal places, i.e. 0.001 g), a thermostatically controlled oven and a laboratory desiccator.

1. Accurately weigh (to ± 0.001 g) triplicate 2 g samples of flour into small dishes and place them in an oven at 104–105°C for two 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:

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

It is also possible to buy a moisture analyser that uses infra-red heat or electrical conductance to measure the moisture content of flour (Fig. 5.2), although they are more expensive than oven drying. If the equipment is too expensive for small scale bakers, samples can be taken to a university food science department or a bureau of standards for testing.

Bakers need to know the capacity of the flour to absorb water, so they can adjust the bread-making process accordingly. A good quality bread flour absorbs water to 60–65% of the weight of the flour, while biscuit flour absorbs water to 55%. Too much absorbed water gives a sticky dough, while too little produces a tough, poorly risen product. A simple test is to make a dough using 100 g flour and measure the weight of water that is absorbed.

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

This is a comparative test that can be used to indicate a wrong grade of flour or to compare new batches of flour with those procured from an existing supplier.

Gluten measurement

For bread-making, it is important that a baker buys 'strong' flour with a medium to high gluten content. For other products, 'weak' flour (lower in gluten) is normally used. Hard wheat flour is often more expensive and difficult to obtain in ACP countries, and it is not unknown for a supplier to substitute cheaper soft wheat flour, or to make an error when labelling the sacks. The gluten content can be checked simply by washing out the starch from the dough and examining the gluten that remains. With experience, a baker can easily tell which type of flour has been supplied.

1. Weigh 10 g 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 (Fig. 5.4). Observe how much it stretches and where the breaking point occurs.

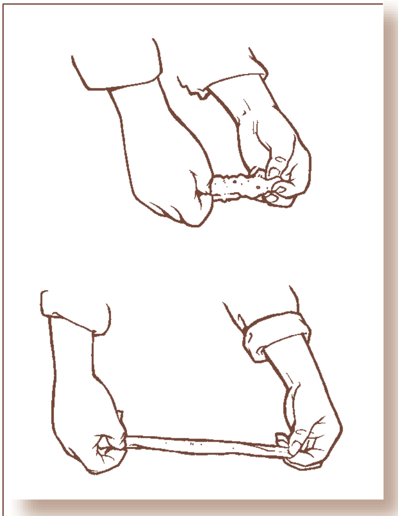

Fig. 5.4 Testing for gluten quality

Starch gelatinisation

Gelatinisation occurs when starch granules in flour swell and burst due to moderate heat and moisture (above 56°C for wheat starch). This gives an increase in viscosity of the starch paste. At much higher temperatures the starch granules burst and the viscosity falls. The degree of breakdown of starch granules can be controlled to give different baked products. For example, starch granules are totally broken down to produce wafer biscuits; there can be a mixture of swollen and broken-down granules in bread; or there can be no breakdown, as in shortbread biscuits. If grain has germinated during storage, there is an excess of natural enzymes that break down the starch, and in products that do not require starch breakdown, this produces a sticky dough. The following test is used to decide whether the enzyme activity in the flour is excessive and allows the baker to adjust the recipe, if necessary. The test assesses the viscosity of gelatinised flour by measuring the time taken by a steel ball 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 1 litre 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 that for a standard flour.

Fats and oils

Solid shortenings (fats) are supplied by large companies in simple paper or plastic wrapping, which offers little protection against rodents, insects or birds. The fats can rapidly develop rancidity if exposed to heat or sunlight, and should be checked routinely by smell and taste. Any rancid fat should be discarded as it will impart an unpleasant flavour to the products. Shortenings are expensive ingredients and should be stored in a cool place away from sunlight, preferably in a refrigerator. They should be used as quickly as possible, with strict stock rotation to prevent losses. If necessary (e.g. when a new supplier is used), the melting point of fat can be checked using a thermometer.

Oil from a reputable processor is usually delivered in tins, to protect it from air, heat and moisture pickup, and hence prevent the development of rancidity. Provided the tins are kept sealed until use and the store is reasonably cool, there should be few quality assurance problems. If oil from village producers is delivered in glass bottles or other containers, 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 require little testing, but they may contain dust and dirt. Their purity can be checked by dissolving a small amount in hot water and allowing any dirt to settle. If salt has a pink tinge it should not be used, as this is an indication of bacterial contamination, which occurs in sea salt originating from lagoons.

Fruit jams or sauces are used as fillings in some bakery products. If necessary, the sugar content can be checked with a thermometer during boiling (jams have the correct sugar content when the boiling temperature reaches 105°C).

Yeast

Yeast is supplied as dried powder or granules, or as a block of fresh pressed yeast. In either case, it is essential that the yeast is active (alive). Dried yeast has a shelf life of one to two years, provided it is stored in an airtight container and kept 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 refrigeration temperatures it begins to lose its activity after only a few weeks.

To test yeast activity, a standard ball of dough is placed in water and timed to see how long it takes to float to the surface. The test is based on assessing gas production (or the activity of the yeast to inflate the dough).

1. Add 5 g of yeast to 100 g 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 taken from placing the ball in the pot until it floats to the surface.

Water

Good quality water is required to form dough and to wash equipment. If mains water is not chlorinated, it should be treated on-site. Details of water treatment are given in Volume 1: *Setting up and running a small food business* (section 5.2).

Other ingredients

Bakery pre-mixes are available in some ACP countries, and these do not generally require testing, provided they are stored under the manufacturer's recommended conditions. Food essences and colours are used in some recipes for confectionery, cakes etc. Essences are supplied in small glass bottles and should be stored in a cool place away from sunlight. Colours are supplied either as liquid concentrates, which are stored in a similar way to essences, or as powders. Powdered colours quickly absorb moisture from the air and should therefore be stored in an airtight container such as a lidded tin or screw-cap glass jar. Quality tests are not normally required on these ingredients.

Process control

After standardised recipes and processing conditions have been established during product development procedures (see Chapter 4), it is necessary to use process control methods to achieve consistent products in every batch. Process control in a bakery involves accurate weighing of ingredients, control over temperatures, and correct timing and handling procedures (Case study 5.3).

Case study 5.3 Importance of QA

Mrs T. underlines the importance of quality assurance because she produces for a particular class of people who will not compromise on quality.
'I maintain quality by carefully weighing the correct amount of ingredients in the recipes, by using the correct baking temperatures and I always have consistent packaging. Above all, I always taste samples from each day's production and those that do not come up to my desired quality are sold to other markets at lower prices.' She also has her products certified by the Ghana Standards Board and occasionally sends samples to the Food Research Institute for analysis.

Control points can be identified to help the baker maintain consistent processing conditions. He/she may need to modify a recipe, or adjust the process to take account of natural variations in the quality of raw materials.

As an example, the checks required at the main control points for bread production are described in Table 5.3. Bakers should produce a similar schedule for all the products they produce. Instruments used for process control include weighing scales, thermometers and timers, and it is important that they are handled carefully and checked regularly for accuracy to ensure consistent test results. The results of tests should be recorded on logsheets and reported to the manager. Operators should be given training to conduct the tests properly, and should be supervised to ensure that accurate information is recorded (Case study 5.4).

Process stage	Activity	Control points
Raw material reception	Flour, sugar, salt, water and yeast brought into factory	Inspection and testing (see text)
Mixing	Ingredients are mixed to form a dough	Correct type and weight of ingredients, dough temperature, yeast activity
Proving	Dough fermentation	Time, relative humidity and temperature in proving cabinet
Dividing and knocking back	Dough formed into balls, gas is expelled	Size/weight of pieces, extent of knocking back
Intermediate proving	To allow yeast to act	Time, temperature, relative humidity in the proving cabinet
Knocking back	Expels gas	No specific controls, consistent procedure used
Final moulding	Forms the final dough shape	Gentle moulding to create a uniform structure having small bubbles
Final proving	To allow yeast to act	Temperature, relative humidity and time in prover
Baking	Dough baked in oven to produce baked goods	Time, temperature (and humidity for some products) in the oven

Table 5.3 Process control points for bread production

Case study 5.4 Process control

A medium-scale baker said: 'To achieve consistent quality products, our manufacturing must be carried out under controlled conditions and in a specified sequence of operations. Process control is required on all aspects and involves checking all control points and materials, production processes and equipment that are used to make a product.' This baker recommends looking specifically at:

- factors (e.g. time, temperature of baking, proving etc.) that affect product quality
- accuracy of equipment used to measure the product
- skills and knowledge of operators
- record-keeping of personnel, processes and equipment.

Cleaning schedules

All bakeries should have a regular cleaning routine, with each operator knowing what to clean, how often and to what standard. For example, those who prepare dough should clean any scraps from the floor as they work, and they should be responsible for cleaning dough preparation equipment at the end of the day. Those who work with the oven or on packing could be involved in cleaning storerooms or toilets while they are waiting for the first batch of dough to be made. It is helpful to produce a list of equipment and the different areas in a bakery, and to indicate how often these should be cleaned and who is responsible for the task. Successful bakers know the importance of regular cleaning routines (Case study 5.5).

Case study 5.5 Cleaning schedules

'We have daily cleaning schedules. All members of staff are familiarised with the cleaning process and one baker supervises. We clean the ovens and all the equipment, utensils and baking tins every day. Then the tables and work surfaces are cleaned and someone sweeps up every day. Sometimes the floor needs washing and this is done about every three days. About once a month we clean everything and scrub the floor, clean the windows, turn out the stores and rearrange the stock. Maintenance of machinery is done at the same time.'

'We don't have a problem with rodents as we clean regularly and try to hose down the premises every week. We keep very few baked products on the premises overnight. We always check that the raw materials store is secure and nothing is kept on the floor.'

'Cleanliness and regular maintenance are the key things. We clean daily after each baking session and wash all equipment, wipe the floor and clean all surfaces. We don't keep any food in the processing area and we make sure that the ingredients store is secure. Regular cleaning of machinery also acts as a maintenance check. I don't believe in waiting for machines to break down before calling someone in. Our machines are inspected as they are cleaned.'

Assessing products

Customers expect bakery products to have an attractive shape and colour, a crumb that is finely and evenly distributed and a desirable texture. The majority of bakery products are assessed by simple visual examination as they are produced. However, the weight of bread is subject to legislation in some ACP countries and sample loaves should be check-weighed to ensure that they comply with the law (Fig. 5.5). An example of a bread assessment sheet is shown in Table 5.4. Numerical values are given to various properties of the product and weighted in favour of the features that are important to the particular bakery. The figures are for guidance and can be changed to suit different products and company requirements.

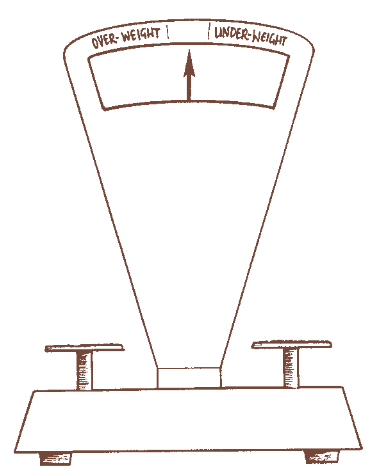

Fig. 5.5 Check-weigher

Loaf type: ______________________

Loaf weight: ______________________ Date: ________________

Loaf code: ______________________ Assessed by: ________________

Loaf characteristics	Target points	Score achieved	Reasons/ comments	Suggested action
Loaf shape	15			
Loaf volume	10			
Crust colour	15			
Crumb firmness or springiness	10			
Crumb colour	10			
Stability of crumb	10			
Crumb cell size and evenness of cells	12			
Flavour and aroma	8			
Eating quality	10			
TOTAL	**100**			

Notes on any faults (e.g. contamination, wrong weight)

Table 5.4 Bread assessment sheet

Loaf volume measurement

An adequate loaf volume is one of the most important characteristics to customers, and a baker can assess this using a device that measures the displacement of rapeseed or mustard seed. This method is accurate because the seeds are hard and round and flow easily to fill small spaces in the uneven loaf surface. A given weight of seed always occupies the same volume.

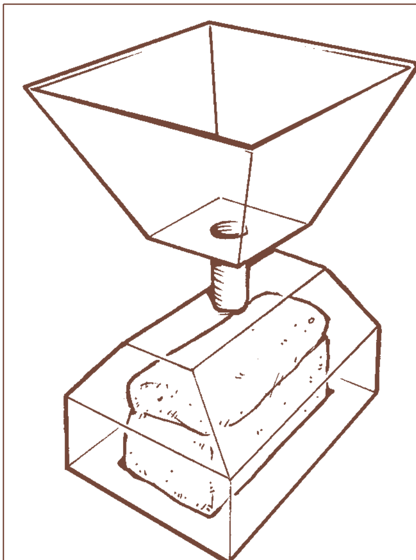

Fig. 5.6 Loaf volume measurement apparatus

The measuring equipment can be constructed locally and consists of two compartments connected by a graduated glass or transparent plastic cylinder (Fig. 5.6). Seed flows into the compartment from the hopper. The tube is calibrated by placing objects of known volume (e.g. carefully measured baked clay bricks of different sizes) inside. The test loaf is placed in the compartment and a known volume of seed is poured in 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 and a score is given (Table 5.5).

Points	Loaf volume (ml)	Points	Loaf volume (ml)	Points	Loaf volume (ml)
1	1270	7	1390	8	1510
2	1290	8	1410	7	1530
3	1310	9	1430	6	1550
4	1330	10	1450	5	1570
5	1350	10	1470	4	1590
6	1370	9	1490	3	1610

Table 5.5 Scores for different loaf volumes

5

Crumb firmness and springiness

In addition to loaf volume, freshness is another highly important characteristic required by customers. The most common method of checking the freshness is a squeeze test. Although assessing crumb firmness is useful, it is easier to measure crumb recovery (i.e. degree of crumb springiness or resilience). This test can distinguish between soft, soggy bread and soft but resilient bread, and assesses how well the loaf returns to normal after squeezing it. Scores are given as follows:

>50% recovery	10 points
45–50% recovery	6 points
40–45% recovery	4 points
35–40% recovery	2 points

Crust colour

Crust colour is assessed against colour standards (e.g. painted cards) as follows:

golden brown	15 points
pale crust	10 points
burnt crust	0 points

Crumb colour

The colour should be uniform, with a maximum of 10 points awarded for an even colour.

Crumb structure and stability

Judgement of these characteristics relies heavily on experience and knowledge of the product. The baker assesses the size and shape of the cells, the thickness of the cell walls, and the evenness of the cells. A total of 12 points can be awarded for crumb structure and 10 points for crumb stability.

Rope and moulds

'Rope' is a problem of bread production, where the crumb has a fruity odour, brown patches and a sticky stringy consistency. This sticky material can be pulled into strings or 'rope' when a loaf is broken open. The problem is caused by a micro-organism that occurs in flour, water and yeast. It can be controlled by buying only good quality ingredients and by thorough baking, followed by rapid cooling of the loaves on slatted shelves to allow air to dry the bottom of the bread. The loaves should not be packed close together while cooling, allowing sufficient space for air to pass between them. Additionally, proper cleaning of equipment, water tanks and surfaces and good personal hygiene can prevent rope.

Moulds also cause bread to spoil. These micro-organisms produce airborne spores, which collect on surfaces and in ingredients. Moulds grow in damp conditions, so bakery products should always be stored in a cool, dry place. Sliced and wrapped bread is more susceptible to the growth of mould because of the relatively high humidity inside the pack and the larger area of moist crumb that is exposed on the slices. Although anti-mould additives are permitted by law in most countries, correct hygiene measures are the preferred option and are more effective in controlling mould. Mould contamination can be reduced by:

- maintaining strict bakery hygiene, including regular cleaning of equipment (especially slicing machines)
- removing all wastes, flour dust and stale food, which can harbour spores
- using a vacuum cleaner rather than a broom to remove dust from floors. This limits the spread of airborne spores

- preventing airborne dust from entering the bakery from outside
- preventing dampness in storerooms
- ensuring that bread is cool before packaging.

Packaging, storage and distribution

There are several reasons for packaging bakery products:
- to keep them clean and protect them against contamination by insects or dirt
- to reduce moisture loss or pickup
- to hold individual biscuits or sliced bread together
- to enhance presentation and aid marketing.

Short shelf-life baked goods can be wrapped in paper or polythene film. Newspaper should not be used because the ink is toxic and may dissolve in the fat contained in the product. If protection against crushing is important (e.g. for cakes, pastries pies), products can be packed in cardboard cartons or loaded onto trays for transport. In each case QA procedures should ensure that the packaging is clean and the products are handled carefully (Case study 5.6).

5

Case study 5.6 QA during distribution

'We use cardboard cartons and wooden boxes to transport the bread and it only becomes damaged when it is packed badly and there are gaps left between the loaves. This is not really a result of bad packaging but of careless transportation.'

Biscuits require more sophisticated packaging to give a shelf life of more than three to four months in tropical climates. QA procedures for biscuits should ensure:
- the packaging is made of the correct type of plastic, and has the required thickness
- there are no holes, tears or punctures in the film
- the seal is correctly formed and has the required strength.

Apart from visual examination, the procedures and equipment for testing plastic films are likely to be too expensive for most small bakeries. Further information can be found in packaging textbooks described in the bibliography.

Stores used for baked products should be cool, dry, regularly cleaned and protected against insects and rodents. Mobile racks or steel shelving with adjustable supports are easy to inspect and assist stock rotation. Slotted high-density polyethylene or polypropylene trays are easily cleaned and stacked, and they can store a variety of different products together on the same tray. 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 is needed to prevent unnecessary wastage and to maximise profits. Normally, short shelf-life products are sold within a day or two, but they should be checked daily. Weekly checks should be made on other products and on raw materials. Stock rotation of products is easier to operate using date coding, but most bakery products do not legally require a sell-by date (see section 5.4). Producers can use a date stamp on packages or trays for their own benefit or alternatively adopt their own code (e.g. a blue card for Monday, red for Tuesday etc.) to identify the date of production (Case study 5.7).

Case study 5.7 Batch codes

'We do check the quality of all raw materials when they come in, such as check-weighing on receipt and occasionally taking samples for analysis. Processing has critical points that we take care of, and storage is supervised. We use batch codes and date codes and occasionally take samples to check out the shelf life.'

The required frequency of QA checks depends upon the importance to the quality of the product and the likely problem that is being checked for. Checks that are critical to product quality or safety should be done for every batch (e.g. the oven temperature) or every day (e.g. mill settings). Other checks are required less frequently, and a summary is given in Table 5.6.

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

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 a 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 they remain appropriate to the needs of the business

Table 5.6 Frequency of QA checks

5.4 Summary of legislation

In most ACP countries there are laws governing the setting up, registration and operation of bakery and milling businesses. Failure to follow the law may lead to punishment by the authorities or forced closure of the business. However, legal requirements vary in different countries, and the details below are given for guidance only. Millers and bakers should check their local laws with the relevant authorities, such as the Bureau of Standards or Ministry of Trade. In summary, the registration of a mill or bakery involves some or all of the following, depending on the country concerned:

- registration of the enterprise with the Registrar of Companies, Ministry of Commerce or 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 the 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.

Flours and bakery products made by small-scale producers are rarely exported and legislation covering exports and international trade is therefore not included. If required, this information can be obtained from the United Nations Committee on Trade and Development (UNCTAD) (see Appendix II).

Food regulations and standards

In most ACP countries there are general regulations that apply to all foods and standards that are specific to particular types of food. Volume 1 in this series contains details of the general regulations concerning labelling, presentation and advertisements, weights and measures and hygiene practices during processing and handling. Millers and bakers should contact either the Health Ministry or Food Commission for details of laws relating to public health, food safety and hygiene and sanitation on their premises. The Ministry of Commerce and Trade or Trade and Industry will deal with laws relating to commodity standards. The Codex Alimentarius Commission (see Appendix II) sets the standards for many raw materials, processed and semi-processed foods. Each member country has a focal point where information on Codex standards can be obtained, either at the Ministry of Health, or Ministry of Trade and Industry.

Regulations concerning flours

All chemicals used during the production and storage of grains are regulated by international laws, described in detail by the Codex Alimentarius Commission. These laws also specify the maximum residue limits for pesticides etc. in grains. Millers in particular should contact the Bureau of Standards or Ministry of Agriculture to find out which of these international laws has been included in legislation for their country. Flours are normally required to have a maximum 15% moisture content, and in some countries the grade of flour is specified by the size range of the flour particles and the percentage bran that is allowed.

Labelling

Unpackaged flour, sold loose and dispensed into customers' own containers, does not require labelling. Packaged flour should be labelled with the name and address of the miller and the name of the flour i.e. not the brand name but the type of flour (e.g. 'soft white flour', 'wholemeal flour' etc.). The law may require the labelling to describe flour that has a specific extraction rate (see Chapter 4, section 4.3). Legislation in some countries allows for up to 200 mg/kg of ascorbic acid (vitamin C) to be added to wheat flour as an improver although, in practice, bakers generally use less (50–100 mg/kg). 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 (Chapter 4, section 4.2) should conform to specifications of the Protein-Calorie Advisory Group of the United Nations (Appendix II), if the government has adopted these. As a minimum, the label on weaning food containers should have a clear set of preparation instructions in the language spoken by customers, diagrams to illustrate preparation procedures and feeding guidelines (frequency and amount). Label instructions should be fully tested among consumers of all education levels and cultural backgrounds to ensure that they are properly understood (see Mitzner *et al.,* (1984) for further information).

In some countries, speciality flours for consumers who have specific dietary requirements are also labelled to indicate the type of nutrients or the composition of the food. For example:

High fibre white flour
Dietary fibre 6%

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 the 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’, ‘healthy’, or can ‘cure disease’.

Regulations concerning bakery products

There are usually no legal limits governing the amounts of flour, shortening, salt, milk or sugar used in bakery products. In some countries standard bread has a required maximum of 38% water, 3% non-wheat flours and 0.25% yeast (each as a percentage of flour weight). Other ingredients, such as soya flour, poppy seeds, caraway seeds, cracked wheat or oatmeal, may be specified to not exceed 2% by weight of the flour. Brown bread may be required to have at least 0.6% fibre. Other speciality breads may be required to 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
Wheatgerm 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

Other additives may have legal limits imposed on their use (Table 5.7), although these are not used often by small-scale bakers. The composition of most chemical additives is also controlled by law, but few small-scale bakers have the expertise or facilities to test their additives for compliance.

Ingredient	Typical maximum permitted level
Oxidants (e.g. potassium iodate, calcium peroxide) and monocalcium phosphate	75 parts per million
Calcium propionate	0.75% of flour weight
Spices	No limit
Colourings	No colouring spice permitted e.g. turmeric
Emulsifiers and dough conditioners (e.g. calcium- or sodium-stearoyl lactylate, polysorbate or succinylated/ethoxlylated monoglycerides)	0.5% of flour weight
Mono- and diglycerides	No limit
Propionic acid/sodium propionate	0.3% of flour weight

Table 5.7 Examples of typical maximum levels of additives in standard white bread

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, *samosas*, flans or pastries should be described with the generic name of the ingredient (e.g. 'fish', 'meat', 'cream', 'fruit', 'cheese', 'nuts' etc.). It is not necessary to indicate the actual type of meat, fish or fruit that is used, although this may help with marketing and promotion. In some countries bread should only be described using one of the following names:

- white bread
- brown bread
- wheatgerm bread
- wholemeal bread
- soda bread
- granary bread.

Packaged goods 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 may have to 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, or a bleaching agent in flour, when the final product is bread). Essences do not need to be individually identified, but simply described on the label as ‘flavourings’.

If there are compound ingredients (i.e. an ingredient 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 supplies 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 Centre for the Development of Enterprise (CDE) in capital cities, or by contacting UNCTAD (see Appendix II). The ingredient list must show a category name such as ‘preservative’, ‘colour’ or ‘emulsifier’ before the E-additive or number (e.g. ‘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 in most countries the weights of standard loaf sizes are controlled by law. For example, in some countries loaves must weigh 400 g or a multiple of 400 g. In other countries the standard weight is 500 g and multiples of 250 g up to 2000 g. Above 2000 g the multiples are 500 g.

A date mark is required for products such as biscuits that have a shelf life of less than 12 months, and for products such as pies that are sold in packages and intended to be eaten after a few days' refrigeration. This type of product is uncommon in most ACP countries and the detailed labelling requirements are not included here. If in doubt, bakers should consult the local Bureau of Standards for their national regulations. Other bakery products do not require date marking if they are normally eaten within 24 hours, even if they are packaged.

Summary of the chapter

- ✔ Identify control points in your process to assure product quality. Do not forget storage and distribution
- ✔ To obtain high quality raw materials and ingredients, millers can consider contracting farmers and bakers can consider making formal agreements with suppliers
- ✔ Assess all raw materials to ensure they have the required quality
- ✔ Develop routine cleaning programmes and ensure they are properly implemented
- ✔ Develop routine methods to assess product quality
- ✔ Know the laws that affect your products
- ✔ Ensure that production methods are suitable for making products that are legal
- ✔ Make sure your labelling meets legal requirements
- ✔ Seek advice from the Bureau of Standards if you are not sure

Entrepreneur's checklist

❑ Do you know what the control points are for each of your products?

❑ Do you routinely check the quality of your raw materials or ingredients?

❑ Do you use this information to improve supplies?

❑ Do you have contracts with suppliers? If not, have you assessed the benefits of agreeing contracts?

❑ Do you have routine cleaning schedules? Are they satisfactory?

❑ Do you routinely check the quality and (where appropriate) the fill weights of your products?

❑ Does your labelling comply with the law?

❑ Do you know where to get advice on the law relating to your products?

❑ Do you have the necessary approval and certificates?

Readers' notes

Please use this space to make your own notes on Chapter 5.

Planning and managing production 6

6.1 Roles and responsibilities within the business

Managing a bakery or milling enterprise means having full control over what is happening in the business. It involves aspects such as planning, purchasing, production, marketing, finances and managing the staff who work in the business.

> *Join local trade organisations. You will meet people who have been in the business longer than you, and membership helps you to look beyond what you have achieved*

At the smallest scale of operation, where the business owner works on site and supervises a few workers, there is often little differentiation in the roles that each person has in the production process, and each worker can do all the different jobs. Owners or managers decide which production tasks workers will

Tips for success

Staff management

✔ Be involved but also be ready to delegate duties to others and play a supervisory role

✔ Build good relationships with your staff

✔ Motivate your staff and invest in them whether it is in salaries and allowances or training. Give them no reason not to be trusted

Business management

✔ Focus on improving your business; never be satisfied with just making profits

✔ Proper record keeping is vital. Keep records of everything and take time to analyse them

✔ Understand the different aspects of your business and monitor the business environment closely

Successful operation of a flour mill depends on:

✔ Having timely and correct maintenance done by qualified personnel

✔ Using cleaned grains at the correct moisture content

Successful operation of a bakery depends on:

✔ Correct scheduling of ingredients for particular products

✔ Using good quality raw materials

✔ **Finally:** Read sections 4.1–4.7, 8.1–8.2, 10.1–10.5 in Volume 1: *Setting up and running a small food business.*

do throughout the day, and do all the other work (e.g. accounts, sales etc.) themselves. However, once the size of the business increases, it is better to give specific roles and responsibilities to different people. This not only increases the efficiency of the operation, but also enables people to specialise and develop their skills in a particular area. Examples include workers who are able to look after a mill and adjust it for optimum performance, or oven operators in a bakery who know how to achieve maximum productivity, product quality and fuel efficiency. As the business grows, there may be further differentiation of jobs.

> *Big bosses should not be embarrassed to help clean up.*
> *Roles may be defined, but if the manager can drive the delivery van to meet a deadline, he/she should do it.*
> *Making money should not be the driving force – be passionate about the business.*
> *Get personally involved in the business and don't be too trusting. You have to check that you are not losing any raw materials or other resources.*

Four examples of roles within bakery and milling businesses are given in Case study 6.1, starting with a small-scale operation and increasing to a medium-scale business.

Case study 6.1 Four types of organisation and roles within a bakery or flour mill

Ms P. is the sole proprietor and takes all the major decisions affecting her bakery business. She takes on more people, as needed, to meet her orders, especially during festive times. She makes decisions about business development with her husband and son who are business partners. She discusses the recipes, production, markets and general business operations nearly every day with her son.

'My wife is the Managing Director and she oversees the running of the business. My daughter is an accountant and she ensures that proper books are maintained. She also works closely with an audit firm, which has been contracted to check the accounts and make sure that we operate within the law by paying taxes and keeping correct records. I help with sales and marketing and purchase of raw materials, and we have a supervisor who oversees the production. We all meet together every six weeks and discuss any outstanding issues. We all expect to play an active role in running the business, although the final decisions are left to me.'

'Three of us head different teams. Production is headed by my brother, who has a catering background, while sales and marketing are handled by another brother. Then there is administration, purchasing and accounts, which I am currently heading. But the roles are changing, and I am going to be concentrating more on fabrication and improvement of equipment for a new site.'

'In our business we have a production manager, who deals with production and machinery; a quality assurance manager, who deals with quality of raw materials and products; an administration and logistics manager, who organises ordering of raw materials and delivery of products; an accounts supervisor, who deals with all accounting issues; a personnel and security man, who deals with staff affairs and recruitment and finally, the Managing Director who oversees the overall running of the business.'

6.2 Production planning

Planning is essential, not only when a business is being set up (Chapter 2, section 2.1), but also for daily operation. Good production planning makes the best use of people, materials and equipment, and also helps the entrepreneur to:

- think ahead about the business to prevent problems arising during operation
- avoid 'bottlenecks' in the process, or running out of an essential ingredient
- know if the business is going to make profits in the future
- obtain the necessary information for bank loans, suppliers' credit etc.
- predict the growth of the business and decide what actions are needed to achieve it.

Small-scale millers and bakers often fail to perform adequate production planning and production may cease due to a lack of spare parts for machinery, or the business runs out of labels, or an important ingredient such as sugar. In the authors' experience, these failures in production planning are the most important reason for a business to operate below its expected capacity. Production stoppages and low production rates mean that the fixed costs (see Chapter 7) become a relatively large proportion of total costs. The business simply does not make enough product (and hence does not receive sufficient income) to make a profit or even to pay the bills. The products then become over-priced and uncompetitive. In extreme circumstances the producer reaches credit limits with suppliers, who eventually refuse to provide inputs, and the business fails.

The following questions illustrate some of the routine planning decisions that need to be taken in a milling or bakery business:

- are enough raw materials available for next week's production and are they of the correct quality?
- is the equipment ready for the expected production levels?
- are there enough packaging materials available?
- are trained workers going to be available, or should extra workers be hired for the week?

Expected sales

A bakery or mill manager should ensure that sales and marketing staff discuss with production staff the amounts of products required each week. There are two reasons for this: first to plan the production levels for the near future, and secondly, to monitor long-term trends. Sales people gather orders from customers, and production staff then draw up a production plan showing how much of each product should be made during the next few days. The production manager can then arrange for the necessary amounts of ingredients, packaging and labour to be available to meet the orders (Fig. 6.1). Clearly, the more notice that can be given of anticipated sales, the easier it is to plan the production (Case study 6.2).

> *If you have sales staff, ensure that they are properly trained, motivated and managed.*

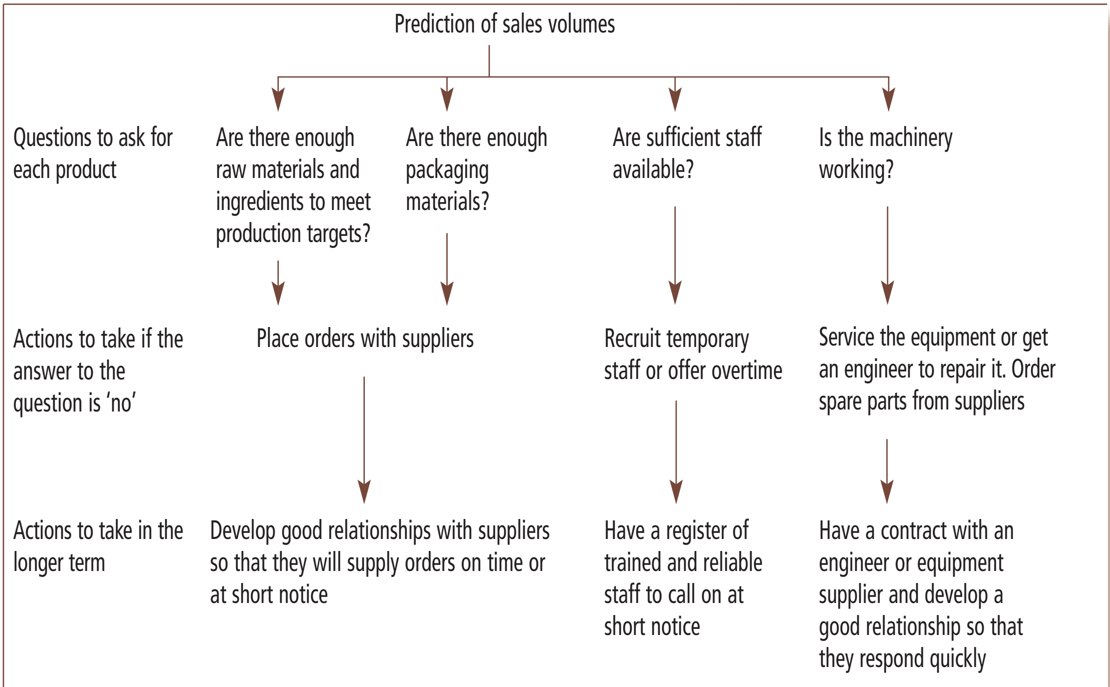

Fig. 6.1 Planning production based on sales predictions

Case study 6.2 Production planning

'We plan our production the previous day, working closely with the staff, and that's when any new orders are catered for. We encourage customers and potential customers to give us enough time, asking for at least two days notice of when they want their orders.'

'We monitor our production very closely so that we produce only what is needed for an order or for that day's sales. Time-keeping is very important to us and we make sure we fulfil our agreements and deliver on time. This starts with production and follows through to delivery. If, for some reason, a customer cannot collect products at short notice, we will deliver.'

Sales staff should discuss the popularity of each product with retailers and customers, and find out whether demand is increasing or decreasing.

By doing this, they can get an idea of future sales trends. This type of information allows the owner or manager to draw up long-term plans to cope with expected changes in demand (Case study 6.3).

Case study 6.3 Business planning

'Planning involves constant dialogue and feedback with both the workers and the customers so each knows what is expected of them. I picked this up during my training in business planning, so I was able to get involved in writing the plan and supervising its implementation.'

'We have developed business, marketing and production plans. We are able to meet the production plan target but production has been adjusted down until the marketing plan is fully implemented and sales increase. We meet and compare sales month by month and try to understand the trends. We are confident that the sales targets will be met, but it's going to take more time and a little more observation of the markets and our competitors.'

The first step in production planning is to get up-to-date information from current sales. Among the records kept by a business, a sales book gives the amount of product sold each day. By adding the daily sales figures to form monthly totals, it is possible to produce a sales graph that shows the trends in sales for each type of product. These figures can then be used to plan for the purchase of additional equipment, to train new staff in time for the expected expansion, or to develop alternative products. For example, in Fig. 6.2, sales of currant buns are steadily increasing and provision for extra production capacity should be planned, whereas sales of doughnuts are steadily declining and a future decision on whether to continue their production may be needed.

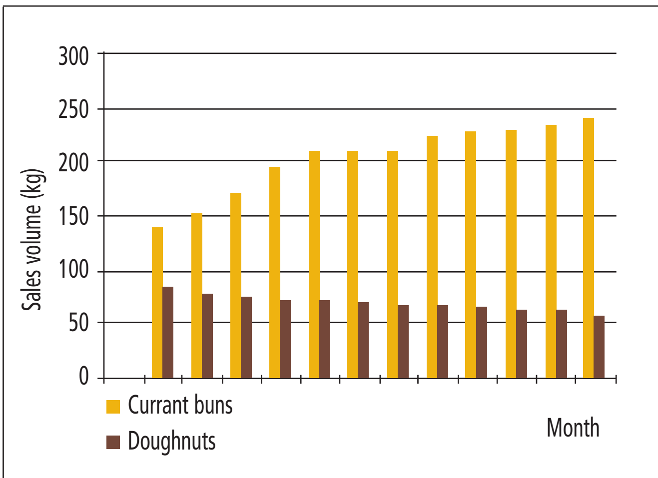

Fig. 6.2 Example of a sales chart

6.3 Managing production

Milling and baking are highly competitive types of business, and good production planning and management are needed to control expenditure and reduce product costs, in order to maintain or increase a company's profitability (Chapter 7). The main considerations are:

- locating sufficient amounts of raw materials and ingredients that have an acceptable quality
- proper staff recruitment and training to ensure a uniformly high product quality
- maintenance of equipment to prevent breakdowns and ensure uninterrupted production
- full utilisation of staff and machinery to maximise productivity.

Each of these is described in more detail below.

Inputs of raw materials, ingredients and packaging

In many ways production planning in a flour milling business is more straightforward than some other types of food processing; the range of products is more limited, the same equipment is used for different products, there are few ingredients, packaging is relatively simple and packaging materials are usually available. However, the need to secure a supply of raw materials, often for a full year's production, poses a major constraint and may involve careful negotiations with farmers or other suppliers. Ideally, there should be strong, trusting relationships between farmers and millers. Strong relationships have several benefits:

- reduced uncertainty, in both costs to the miller and income for the farmers
- increased profitability from an assured supply of high quality raw materials
- reduced costs arising from buying activities, better production planning and cash flow management because of guaranteed raw material supplies
- better understanding by farmers of millers' quality requirements and increased incomes to farmers from guaranteed sales of crops.

A key component of any agreement with farmers is the price offered by the miller. A number of arrangements are possible to determine the prices that are paid for crops. In contract growing schemes, the miller sets a fixed price and the farmers have a guaranteed income, but do not benefit if the market price rises. They are more likely to renege on the agreement under this type of contract and sell their crop to the highest bidder. In contract milling schemes, the miller buys a proportion of the crop at a fixed price and the remainder belongs to the farmer. This places the risk with the farmers, but also gives them the opportunity to get the full market price for part of their crop. For any type of agreement to be effective, both parties must keep their side of the arrangement, and this requires a high level of trust and understanding. Case study 6.4 illustrates four different arrangements between millers and farmers.

Case study 6.4 Contracts with cereal farmers

'Our principal raw materials are maize, sorghum and millet. To ensure that the factory has enough high quality raw materials, we have made contracts with farmers that cover a specified period (usually one year). These contracts emphasise the timely delivery and quality of grains to be supplied. In fact, the owner visits some of the farmers to ensure that the correct varieties are supplied.'

'My biggest cost is transport. I do not own a company truck and this means that suppliers use their own transport and thus the charge for the raw materials is higher. We have budgeted for our own truck and then we will be able to go to the villages and buy the crops ourselves. This will also give us more say in the quality of the materials that we buy, and we will be able to reach more suppliers than can come to us. I know that this is going to cut our production costs tremendously.'

'We don't have any contracts with suppliers. We buy in bulk and always pay cash. We try to buy from the same supplier as long as he can give us a discount and have supplies when we need them. But we do give him advance warning of our need!'

'The quality of the maize I buy is fairly consistent because I go to the areas of production and buy directly from the farmers. To overcome the problem of high cost during the lean season, I stock up during the bumper season, between August and October.

Bakers require better production planning skills than millers because a wide range of products are needed for an operation to be profitable. When a baker has decided on the amount of production needed each week to meet the expected demand, the weights of ingredients can then be calculated using the recipe for each product (Table 6.1). All other inputs (packaging, labels, distribution, cartons etc.) can then be scheduled, and orders placed with suppliers to maintain the required stock levels. Because of difficulties in securing reliable and regular supplies of ingredients and packaging materials in many ACP countries, some bakers keep large amounts of stock to protect themselves against loss of production. Also some millers buy a year's stock of grain at harvest time when the prices are lowest. The large expenditure on these purchases may cause cash flow difficulties because cash is tied up for many weeks while stock that has already been paid for is waiting to be used. In addition, holding stocks of materials for a long time may result in wastage, spoilage or theft.

The alternative of buying materials more regularly in smaller quantities is often favoured by smaller enterprises to overcome cash flow problems. However, items bought in this way are more expensive than buying in bulk, and there is a constant risk of production stoppage because all the stock of an essential ingredient has been used. The problem can be partly addressed by adequate initial financing of the enterprise, perhaps with a facility to take a loan in phases over several months to meet the planned shortfalls in cash flow, and by periodically buying materials in bulk.

Feedback from small-scale millers and bakers revealed that raw material and ingredient costs represent a significant proportion of total production costs (between 30 and 80%, with an average of 52%). Raw material costs therefore have a significant effect on the profitability of the business, and it is important to ensure that materials are correctly ordered and checked upon delivery. (Details of quality assurance checks are given in Chapter 5.) Case study 6.5 illustrates some of the arrangements operated by successful bakers.

Product: Banana cake	
Recipe to make 30 kg cake (from Table 4.12):	
Flour	10.0 kg
Baking powder	150 g
Sugar	6.25 kg
Water	5.0 kg
Eggs	2.4 kg
Shortening	5.0 kg
Banana (pulped)	7.4 kg
Production target:	300 pieces of cake @ 100 g each (30 kg total)
Losses during preparation and baking = 10%	

	Amount required for target production (kg)	Amount in stock (kg)	Amount to be ordered (kg)	
			For production	For stock
Flour [1]	33.0	150	0	0
Baking powder [2]	0.51	1.5	0	1.0
Sugar [3]	20.6	12	9	25
Water	16.5	–	–	–
Eggs [4]	7.9	0	8	0
Shortening [5]	16.5	15	1.5	10
Banana (pulped) [6]	24.4	0	25	

[1] There is sufficient flour in stock, no order required

[2] Order to replenish stock

[3] Order to have sufficient for production and to replenish stock

[4] Order for production, only fresh eggs used so no stocks kept

[5] Order to have sufficient for production and to replenish stock

[6] Special purchase of pulp from fruit processor

Table 6.1 Calculation of ingredients required for a day's production

Case study 6.5 Buying ingredients for a bakery

'We replenish our supplies depending on the size of received and anticipated orders. This can be seasonal – sometimes we have to stock up fully, especially during the school term, and at other times we just buy enough for weekly production. We have contracts with the suppliers and we pay them 75% on placing an order and the balance when goods are dispatched. If you maintain a good relationship with suppliers then you are sure to get good stuff.'

'We have a contract with the flour supplier and we are given 7–30 days' credit depending on the quantities we buy. Other ingredients are bought from people we have dealt with for some time and have built good relationships with.'

'When I go shopping, I try to visit all my suppliers for a chat. This normally reveals a lot of information that we would otherwise not be able to hear. So we always know whose flour stays longest on the shelves and which suppliers tamper with labels. I buy on credit and pay after a week or two when I have used the stock. I try to buy in bulk to reduce costs, but I also try not to overstock.'

'Raw materials are probably the highest cost in production. We have tried to reduce costs by buying non-perishables in bulk. I spend quite a bit of time comparing prices and trying to get the best deal.'

Keeping too much stock means that money is tied up and is not earning interest in the bank. Overstocking or failing to check stock regularly has other disadvantages:

- if sales patterns change, the producer may be left with stock that is not useable
- if stock records are not checked it is possible to order the wrong quantities at the wrong time
- you won't know if stock is missing, damaged or in poor condition or if the storage life is about to expire.

It is therefore important to do regular stocktaking and to keep records of the stock to know when to re-order, what to order and how much to buy.

Similar considerations apply to ordering packaging materials. Costs of packaging vary from 5–25% among companies interviewed for this book. Most millers and bakers are able to find a local source of paper or polythene bags to wrap their products (Case study 6.6). However, problems arise if a special film is needed that is not available locally. The need to order large amounts from overseas suppliers, together with the higher cost of specialist films, can have a substantial effect on the cash flow of a small bakery. In some cases, the lack of affordable packaging prevents the production of these products.

Case study 6.6 Overcoming packaging problems

An experienced baker in Malawi produces a popular type of biscuit that has an artificial cream filling and requires a polyester or polypropylene film to give it the required shelf life of four to six months. He had great difficulty in finding affordable supplies of the film and temporarily ceased production. His eventual solution was to buy a different film that was relatively cheap and easily available, and then modify his product recipe to suit the packaging material. After shelf life testing, he found that the modified product stayed fresh in the new film for six months and he was able to resume production.

'We use polythene bags for packing bread and small cakes and boxes for larger cakes. The polythene bags are sold in kilos, and you can select the gauge and level of transparency you need. Plain boxes are easily found in town, but they are expensive if you want them printed.'

'Our products are packed in paper bags, obtained locally from a contracted supplier. Packaging costs represent 25% of total production costs, but the proportion goes down if bulk orders are made. Unfortunately, there is a lack of competing local packaging companies, giving this one a monopoly, and the prices are high.'

'Printed labels are expensive, but since that is our way of advertising the products, we get good quality labels despite the price.'

Recruiting and training staff

Manpower (or human resource) planning means making decisions on the present and future staffing needs of the enterprise. Larger companies have a systematic approach to recruiting and training employees, which has substantial benefits. Such an approach is also likely to benefit small companies, but requires the owner or manager to develop company policies and terms of employment, as described in Volume 1: *Setting up and running a small food business*.

Among small-scale millers and bakers, opinion is divided as to whether it is a good idea to employ friends and relatives (Case studies 6.7 and 6.8). Although friends and relatives can usually be trusted, they may not have the best skills for the job.

Case study 6.7 Employing friends and relatives

'I have tried to involve the family as much as possible, but some are interested and others are not. I normally get staff by recommendation from friends and acquaintances.'

'My staff were all recruited locally and most are relatives. Of late we have started to recruit people with experience because family members were not expected to have that.'

'Most of our team are relatives. I think that if we had to do it all over again we would still hire them. The old adage that "a business should keep the family at bay" has been proved wrong in our bakery. We hired family and friends because we didn't have much money when we started, and we knew that staff would have to go without allowances sometimes. We hoped they would understand – and they did.'

'The company employs 40 people who were recruited with a preference for young healthy married people with a level of education and experience. Family members are given preference.'

Case study 6.8 Employing non-relatives

'We decided to employ people who had some formal training in bakery for the top positions and home economics students at the bottom. Staffing is an area that can either make or break a business and although there was pressure from the family to be considered, we stood our ground. This has been beneficial.'

'We advertise our vacancies and conduct interviews. We look for qualifications and experience, depending on the job. From experience, I discourage employing relatives, but I have managed to get some reliable staff and I can train the weaker ones.'

'Experience is important, so is age. We prefer someone who has a minimum of O-level standard education and who is faithful, available and teachable (FAT)!'

'I need to be sure that I can trust the staff. There is no guarantee that I'll get the right ones every time but I try my best to employ staff with references.'

Planning work for staff

Staff need good training and management if they are to be effective and efficient. An activity chart (Fig. 6.3) can be used to plan the different jobs that each worker does during the day. It shows the type of work and the sequence of activities for each worker.

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

Fig. 6.3 Activity chart used to plan job allocations for bakery staff

Depending on the particular ACP country, labour costs can be a relatively high proportion of total production costs. Bakers and millers reported labour costs to be between 5% and 50%, with an average of 17%. The high costs of staff and staff training mean that it is important to keep experienced staff. However, many owners of small businesses refuse to train their staff because they are worried that the staff will ask for higher pay or will move to a competitor. Both attitudes are short-sighted and could eventually cause the business to fail.

As in other aspects of running a business, the owner or manager should have a wider view of where the business is heading and what is needed to get it there. Staff development is an important aspect of forward planning, and the business should be willing to invest in its employees.

There are different types of training, but all should build up in a systematic way, developing skills, knowledge and attitudes that are relevant to the job. 'On the job' training either involves the new employee working immediately in his or her normal job under the supervision of more experienced workers, or the employee can do different jobs to gain experience of the whole operation. If staff are trained to do different jobs, the business will have greater flexibility to deal with absenteeism, holidays etc. Details of selected institutions offering training in bakery and/or milling are given in Appendix II. Case studies 6.9 and 6.10 illustrate some experiences with staff training and motivation.

Case study 6.9 Experiences of staff training

'I have tried to keep the number of workers to a minimum, but since we are thinking of expanding, I am preparing my staff to take on more roles as opposed to hiring others. We are training them to handle different areas and we are paying them overtime for the training.'

'We provide on the job training and also send our staff to a baking training school, where they can interact with other bakers.'

'Although it is easier to train an experienced person, one has to deal with their working culture which is much more difficult to change than with an inexperienced worker. Hence we prefer to teach somebody with no idea rather than somebody with their own idea.'

'We had a few sessions of in-house training from a baker at a reputable bakery in Kampala. Three of our top staff attended a three-week course in Kenya, and are now able to train others. Some staff still need training in recipe formulation and safe handling of foods. I think we will also need training in cake decoration, but this is for the long term.'

A successful business of any size will have workers who feel rewarded and are willing to work for the company because they have a future in it. Motivation is an important part of staff development and encourages employees to achieve their highest level of performance.

Staff gain satisfaction from their jobs if they receive reasonable pay and have good working conditions, together with management methods that motivate them so that they enjoy their work. Well motivated staff have limitless potential in their individual jobs, and improve the overall productivity of the enterprise (Fig. 6.4). Managers should therefore devise ways of motivating staff and improving job performance. Examples of staff benefits identified during interviews with bakers and millers include:

- competitive salaries and regular review of salaries, prompt pay and extra rewards when the business does well
- paid overtime
- paid leave and holidays
- interest-free and flexible loan facilities for school fees, during bereavement, with rent and other family needs
- free meals, lunch allowance or food allowance
- staff discounts for products

Fig. 6.4 Motivated staff are efficient and productive (Photo: L. Gedi)

- sick pay and sick leave, hospital and health care benefits, paying medical bills, medical examinations [1], or a proportion of salary held for medical support costs
- toilets and washing facilities with hot water
- transportation to work or transport allowance
- representation or attendance at staff meetings
- uniforms, aprons, head scarves and work clothes.

Even the lowest paid worker needs a sense of security, recognition and belonging. The terms and conditions of employment vary widely in ACP countries but, as a minimum, managers should give workers contracts of employment and encourage a sense of status and pride at all levels to help employees identify themselves with the enterprise.

> *Train your staff to bring them up to standard.*
> *Give polite tips when you think staff members are not being very strict with rules.*
> *Pay your workers well.*
> *Go for further training, attend seminars and workshops and also visit other organisations/companies that have experts in your field of operations to improve the performance of your business.*

6

Case study 6.10 Keeping and supporting staff

'We have accepted the bitter truth that another business out there is always trying to get our staff. Our working environment is good and the staff have their own representative who sits in on management meetings. We try to keep the relationship between managers and staff as open as possible.'

'We try to offer good conditions of service, but the industry has a high staff turnover due to the mushrooming of new bakeries. They poach labour and it is hard to keep a skilled workforce.'
'The workers have proper contracts stating their terms and conditions, so job

[1] In many ACP countries, staff are required to undergo a medical examination to obtain a health certificate for working with foods.

security is assured and I doubt that they will just leave. A lot of workers in this industry live under the threat of dismissal, so my workers are quite happy with the arrangement. I also try as much as possible to address any issues they raise. I can't perform miracles and they know it, but I listen and if I can help I will.'
'We try to keep the same staff and improve on their terms annually. The surest way of losing workers is underpaying them when you can do better.'

'Our staff appreciate the training they get and we emphasise that we are not stopping any of them leaving as long as they serve at least two years. They sign a contract to this effect and then they are free to go. None has left us other than for reasons of health or family commitments. We are always ready to listen to their problems and make them feel that they are part of the success of the business and they appreciate us appreciating them.'

'I always encourage my staff to be open and let me know when they want to move on. This open relationship has helped me to keep my workers. Their terms of employment are also good compared with other workers in the milling industry.'

Health and safety

Every entrepreneur has a responsibility to provide a safe and healthy working environment. Many, but not all, ACP countries have laws concerning the health and safety of workers and the safety of equipment, but even if legislation does not exist, the consequences of accidents and illness arising from poor working conditions are far greater than any difficulty in ensuring safety.

> *It is important to have a regular maintenance programme for equipment that would be dangerous if a failure occurred, and all staff should be properly trained to carry out potentially hazardous operations.*

Unsafe working conditions can also arise due to poorly designed workplaces (e.g. lack of adequate lighting, ventilation, slippery floors or steps) and unsafe actions (such as interfering with safety guards or working double shifts without rest periods). These are all the responsibility of the manager or owner.

Simple safety precautions reduce the chance of accidents, and enhance the good name of the company. This increases the confidence of customers in its products, and improves the working conditions and productivity of the staff. Fewer accidents also reduce production losses, repair costs, extra costs of training new staff and medical bills. Simple precautions are listed in Table 6.2.

The most frequent causes of accidents in a mill or bakery include:
- use of cables without insulation
- lack of protective covers on switch gears, fuse-boxes etc.
- use of unearthed equipment
- unauthorised additions to circuits resulting in overloading and fire risk
- bridging over fuses
- improper adjustment and maintenance of equipment
- poorly aligned drive belts to machinery
- poor maintenance or use of incorrect spare parts
- failing to use the correct tools for the machine.

In flour mills, powered equipment, such as mills and hullers, should always have guards in place over drive belts, and staff should be trained in safe operating procedures. The manager should also prevent operators from wearing clothes or jewellery that could become entangled in moving equipment. Dust produces an unhealthy working environment and the manager should provide ventilation and/or ensure that it is extracted from the plant to maintain a healthy workplace. The potential for a fire in bakeries and flour mills is very real. It can be caused by ovens, by airborne dust or by overheating of electric motors, and managers should ensure that a bucket of sand or an operational fire extinguisher are provided and are easily accessible. In the event of an electrical fire, the electricity should be turned off at the main switch and the fire either smothered with a damp cloth or put out using sand.

Water should never be used to extinguish an electrical fire.

In bakeries, the main dangers are due to heat and steam and safety measures are needed to protect workers against burns and breathing fumes or smoke. A bakery manager should ensure that workers are provided with heat-resistant gloves to handle hot baking trays. Fire extinguishers should be kept close to the ovens. There are also dangers from moving equipment (as above), especially from mixers. Guards should cover the mixers and they should have a working failsafe mechanism to ensure the mixer stops automatically if the guard is removed.

Safety tips for flour mills and bakeries

1. Do not allow customers, children, visitors or animals into the mill or bakery building. Ensure that only trained staff enter the premises and operate the machines.
2. Prevent staff wearing any loose clothing (e.g. ties, un-buttoned or long-sleeved shirts) that could become caught in running machines. Provide them with overalls.
3. 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.
4. 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.
5. 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.
6. Train staff to be familiar with potential hazards (e.g. potentially dangerous machines or hot surfaces), and make sure they know what to do in the event of an accident. Use charts hung on the wall near each machine to show safety precautions.
7. Ensure that guards are fitted and in place over all moving parts of a machine and alert staff to machines that appear to be standing still when running at high speed.
8. Never allow staff to clean, adjust or lean over moving machinery and do not allow them to leave a running machine unattended.
9. Encourage operators to report any loose parts on a machine.
10. 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'.
11. Do not allow anyone to touch inside electric equipment while it is connected.
12. Regularly check the cords of electrical appliances to ensure that outside covers are not broken and wires are not exposed.
13. Prevent staff from running inside a building. Immediately clean up any water, oil or grease on the floor using sawdust, sand, husks etc.
14. Ensure that staff who work in dusty conditions protect their mouth and nose with a mask. Clean the building each day.
15. Have a first aid box containing sterilised dressings, cotton wool, adhesive plasters and bandages. In many ACP countries, the law requires every factory to have one.

Table 6.2 Safety tips for flour mills and bakeries

Services

The cost of electricity, fuel and water was reported by millers to be 5–10% of total production costs, and by bakeries to be between 10 and 20%. Some had calculated the exact amounts and others simply estimated the costs, but their findings were in very close agreement across the range of business types and sizes. The main problem reported is interruption to the supply of electricity, which stops milling altogether, and even in bakeries with fuel-fired ovens, the loss of electricity prevents mixing and so halts production. If services are likely to be inadequate or unreliable, steps should be taken to find alternatives (e.g. a borehole for water, a diesel powered mill or a backup generator). A number of businesses that were surveyed have taken steps to reduce the cost of services (Case study 6.11).

Case study 6.11 Reducing the cost of services to bakeries

'We plan our production so that our machines are not left redundant. Depending on the required temperature, products go into the oven in sequence and there are no gaps when the oven is left empty. Someone supervises the baking so that we do not use more firewood towards the end of the baking session. We set a time to do cleaning to save on water consumption. Even the phone pays for itself because we use it as a public service.'

'We bake everything at the same time to utilise all the heat and cut down on electricity costs. We are considering venturing into charcoal-fired ovens, but this is still on trial.'

6

Maintenance of equipment

Inadequately maintained machines result from attitudes such as those described in Case study 6.12. Machine breakdowns reduce productivity and increase production costs. Lack of maintenance is one of the most common reasons why small-scale millers and bakers lose money. In addition to posing a potential hazard to operators, poorly maintained machines produce substandard products and can contaminate products with metal fragments.

Succesfull operation of a flour mill depends on operating the mill at the correct speed, using the correct motor for the load, and on using a screen with appropriately sized apertures to achieve the required degree of fineness in the flour.

Proper maintenance ensures that machinery operates correctly and safely and prolongs its life, thus reducing capital and operating expenditure.

Most small-scale processors do not have a programme of planned maintenance, preferring instead to rely on the maxim 'if it is not broken, don't fix it'. Some engineers agree with this and regard planned maintenance as unnecessary. They believe that it is cheaper to allow equipment to break down and then repair it. Others consider that it is cheaper to stop production on a regular basis and replace parts before they wear out. On balance, it is probable that the costs and benefits of planned maintenance depend on the speed at which repairs can be done and the value of the spares that have to be held in stock.

As a minimum, managers should monitor the state of equipment and facilities that are likely to wear out. As experience of the rate of failure accumulates over the years, they should buy spare parts or send the machine for servicing when the next replacement is anticipated.

Case study 6.12 Attitudes towards maintenance of milling machinery

Poor attitude:

'My job is to operate the machines. It's not my job to take good care of them. If a machine breaks down, I will ask the maintenance men to repair it.'

'Machines do not break down just because they are not properly cleaned.'

'There is no relationship between quality problems in the finished product and machine breakdowns.'

'I do not have to learn the skills to inspect or repair machines. I can do a good job of producing flour without knowing anything about them.'

'I blame the designer for malfunctioning of the machine.'

And a more sensible approach:
'Cleanliness and regular maintenance are the key. I don't believe in waiting for machines to break down before calling someone in. Our machines are inspected regularly. We do daily cleaning after each baking session when we wash and check all equipment and machinery.'

The following actions are needed to put preventative maintenance into practice:

- identify priority machinery where components wear out more frequently
- write a clear description of the procedures and standards for the work of machine operators and maintenance workers (such as lubricating, tightening bolts, making 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
- update procedures and standards on a continuous basis.

Bakery equipment is relatively robust and does not require the same level of maintenance as high-speed flour mills and hullers. In a plate mill, the plates are the main components that require replacement when they wear down. In areas where plate mills are used there is usually an adequate supply of replacement plates made by local metal casting foundries.

A detailed description of routine maintenance procedures for a hammer mill is given in Appendix I and summarised in Table 6.3. Similar considerations apply to other types of milling equipment.

Daily maintenance

Mechanical

- check and grease bearings, replace if faulty
- check pulley wheels for cracks or chips and replace if necessary 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
- remove flour dust from equipment each day. 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 it causes motors and engines to overheat and burn out or seize

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 so they are easy to find and it will be noticed if they go 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 and nuts are tight. If they work loose, the fan 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 obvious sign of insulation breakdown
- check the acid level in batteries that are used to start diesel engines. Keep the terminals clean

Table 6.3 Summary of routine maintenance for a hammer mill

Maintenance records

Maintenance and spares records (Figs 6.5 and 6.6) should be used to provide information on the performance of equipment. Records help to ensure that maintenance costs are included in the cost of running the business, and to plan purchases of spares, making sure they are available when required.

Date	Work carried out	Parts used	Cost

Fig. 6.5 Maintenance and repair records

Type of spare:				
Quantity purchased	Cost	Quantity in stock	Quantity used	Date fitted

Fig. 6.6 Spares record

6.4 Improving productivity

The bakery and milling companies that assisted in the preparation of this book ranged in size from two to 124 employees, with the majority employing eight to 15 workers (average of 10). The businesses varied greatly in their productivity; for example a bakery with three workers was able to produce 700 loaves, 1000 buns, 500–700 queen cakes and 1000 doughnuts per day, whereas another bakery with 15 employees produced 160 loaves and 200–300 bread rolls per day. Most bakeries produced a range of products, with only one bakery producing bread and buns alone. A good example of the product range from a bakery employing eight people is 30 kg biscuits, 5 fruit cakes, 1000 cup cakes, 250 *samosas* and 100 doughnuts per day, with a further 100 pizzas per week. A similar sized bakery produces 200 loaves, 50 doughnuts and 40 pies per day and five to 10 cakes per week.

Millers were more uniform in their output per employee, largely because there is a greater reliance on the output of the machinery and less on labour intensive craft skills. For example, a mill that employs two workers produces 3200 kg maize flour per day, another employs four workers and produces 4000 kg/day, and a third employs 11 people and produces up to 8000 kg/day.

Productivity can be improved by:
- improved efficiency (e.g. lowering operating costs, reducing idle machine time and reducing waste)
- better procedures for buying materials
- reducing losses of raw materials
- improved decision-making and communication
- increased output by minimising equipment breakdowns and reducing other causes of lost time
- improved organisation, better staff morale and co-operation.

In order to assess whether improvements to productivity are taking place, it is necessary to measure and record consumption of materials, amount of labour used etc. These figures can then be used to calculate for example:
- amount of packaging per kg of product
- labour costs per kg product
- energy used per kg product etc.

> *Productivity can also be improved by changing the design of the product or the 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 (see Chapter 3). Case study 6.13 illustrates some attempts to improve productivity.

Case study 6.13 Improving productivity

'Apart from keeping numbers of workers low and making sure they are as productive as possible, there are no short cuts around this one. When we are not busy we let some of them off early. These little savings on wage bills mean a lot over a month. If they are willing to take on more roles then we can employ fewer staff. They are not forced into anything; we discuss it, and if they agree we implement it.'

'I try to reduce costs by maximising the productivity of individual workers. They have to manage their time well and we teach them how, and supervise their efforts. I will not cut any salaries but if we can get four days work done in two, I am cutting costs.'

'I pay by piecework. The more they produce, the more they are paid. This is a kind of incentive and it keeps numbers of workers low and maximises productivity.'

'To increase productivity, we must be capable of adapting to changing markets by being innovative and creative, by differentiating our product and becoming more customer-oriented to compete effectively.'

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, thereby improving 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 (Case study 6.14).

Case study 6.14 Reducing wastage

'Any left-over products are taken to an evening market and sold at a reduced rate. If any are left after 9 p.m. they are sold at cost price but this has happened only once or twice.'

Although it is possible to sell old products directly from the bakery, this is not advisable for a baker who wishes to maintain a reputation for selling only the highest quality products. Instead the baker should negotiate in advance with caterers, government institutions or cheaper retail outlets to purchase older products at short notice at a reduced price. After two days, any pies, *samosas* etc. that contain meat or vegetables, or cakes that contain cream, should be discarded or burned because the filling is likely to be unsafe. If bread has developed mould spots it is not edible and should also be burned, taking care to thoroughly clean the shelf on which it was standing to avoid infecting future products. If there is no mould, the bread is still edible, but is not attractive and will not be bought. An alternative source of income is to use crumbs made from bread, cake or scones:

- as a filler in meat products
- recycled as an ingredient in some bread recipes
- dried and sold to caterers for coating fried fish or meats
- sold to animal feed producers for poultry feeds.

> *Check what you consider to be waste, it might bring in some unexpected extra income.*
> *Maximise the use of by-products to generate income and avoid siting waste heaps around the mill where they attract rodents and birds.*

Reducing energy use in processing and distribution

Ideas that can 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 and cost-effective fuels
- buying fuel from local briquette makers rather than using fuel-wood
- using local suppliers of raw materials that can be delivered by bicycle or head loads, rather than using a vehicle to collect them. Similarly, making as few journeys as possible to deliver products to wholesalers or retailers.

Reducing noise pollution

Noise pollution is not often cited as a problem, except for large mills in urban areas. If noisy machinery is used, screens can be built to prevent the noise becoming a nuisance to neighbours.

Summary of the chapter

- ✔ Carefully plan production to ensure: 1) adequate supplies of raw materials and packaging are available, 2) sufficient numbers of trained staff are available and 3) all machinery is serviced and in working order
- ✔ Design and implement a regular maintenance programme for machinery and equipment
- ✔ Use sales information to plan daily and weekly production as well as to formulate long-term plans concerning changes to production levels
- ✔ Consider making agreements with both suppliers and buyers to assist production planning
- ✔ Carefully plan work for all staff to maximise their productivity
- ✔ Think carefully before employing friends and relatives
- ✔ Be active and innovative in managing the business
- ✔ Train staff so that they can work to a high standard without supervision
- ✔ Motivate and reward staff to gain their loyalty and deter them from leaving
- ✔ Ensure that the factory is safe and does not damage workers' health
- ✔ Develop ways of improving the productivity of both staff and machines

Entrepreneur's checklist

❑ Do you know how to plan your production to meet demand for each product by:

securing raw materials/ingredients and packaging material supplies?

having sufficient numbers of trained staff?

ensuring that all equipment works properly?

❑ Have you taken steps to improve the productivity of:

your staff?

your equipment?

❑ Are you regularly on site to manage the factory? If not, do you have a trusted manager?

❑ Have you recently reviewed the rewards and benefits that you offer your staff?

❑ Have you made sure that all operations in the factory are safe?

Readers' notes

Please use this space to make your own notes on Chapter 6.

6

Planning and managing finances 7

7.1 Start-up costs

One of the first problems facing a small-scale bakery or milling entrepreneur is finding enough money to start the business. The capital outlay is greater in milling because of the need to purchase the mill and huller, whereas a baker can begin at home using domestic equipment, although it is preferable to start with a separate facility. However, both types of business incur additional start-up costs including:

- conducting a feasibility study and preparing a business plan
- obtaining licences and health certificates
- recruiting and training staff
- buying ingredients and packaging before there is any income from sales.

The initial financing of a bakery or milling business should therefore be based on a detailed feasibility study (Chapter 2, section 2.1) that takes all costs into account. It is likely that funds will be required at different stages (Table 7.1) and this should be planned for when arranging a loan or discussing the business proposal with potential investors. Many small-scale bakers and millers in ACP countries do not wish to deal with banks because of the generally high interest rates, but some positive experiences were reported by businesses during research for this book (Case study 7.1).

Tips for success

✔ If you don't have much capital, start small

✔ Do not take money for personal use out of the daily takings, have an allowance instead

✔ Don't try to undercut others by offering lower prices, this is very dangerous and most, if not all, such people soon go out of business

✔ Have sufficient working capital to buy grain during harvest to mill throughout the year

✔ Make weekly deposits for utilities so that bills don't overwhelm you when they come in

✔ Pay your taxes

✔ Be in the good books of your bankers (no matter how small you are) and be open to them, don't tell them half-truths

✔ Cost your products whenever there are changes in raw materials or other areas of production. This will help you decide when you need to raise your prices

✔ **Finally:** Read sections 7.1–7.5 and 8.1–8.2 in Volume 1: *Setting up and running a small food business.*

Stage	Finance required
Initial idea	Travel to get information for feasibility study and meet potential investors
Planning	Travel to meet equipment suppliers, builders etc.
Establishing the factory	Constructing or modifying a building, installing services, buying equipment, advertising, recruiting and training staff, travel to meet raw material suppliers and retailers
Commissioning	Testing equipment, buying raw materials, ingredients and packaging, establishing production routines, training staff
Starting production	Production costs (see section 7.2)
After start-up	Bulk supplies of raw materials or packaging, additional finance to keep a positive cash flow (see section 7.3)

Table 7.1 Phases requiring funding in a new business

Case study 7.1 Experiences with banks and other financiers

'We have negotiated an overdraft facility so we know that if we ever get stuck there will be a way out. I also obtained a small loan from a relative. This helped to boost working capital after we had invested in some small pieces of equipment.'

'I feel that borrowing from the bank does not help. One continues to be in debt because the budget gets eroded by ever increasing interest rates. The cost cannot be passed on to the consumer because excessive price increases can put you out of the market.'

'The catering component of the business is very profitable and so it can lend to the bakery side without interest.'

'I have so far taken out two loans from my bankers – both of which I have repaid – and I have applied for a third. The bank gave me advice when I presented the business plan and helped with my vision for expansion. They advised that I retain the old bakery for now until the new one is set up and ready to handle the transition. I had not thought about this and I am very grateful to them.'

7.2 Production costs

Fixed costs (or overheads) include office costs, interest on loans, depreciation etc. and are similar for all types of business, but there are differences in variable costs between bakery and milling businesses. For example, data from mill or bakery owners interviewed for this book indicate that the skill level of experienced bakery workers tends to be higher than for production workers in flour mills. This is reflected in salary costs, which form a higher proportion of production costs in bakeries (Table 7.2). Similarly, bakeries that produce a wide range of products may use more expensive packaging (e.g. cake boxes or biscuit cartons) than the simple paper bags or sacks used for flour. In both types of business, raw material/ingredient costs are the largest proportion of production costs.

Type of expenditure	Mill (average % of total production costs)	Bakery (average % of total production costs)
Labour	22	29
Raw materials/ingredients	45	40
Packaging	5	9
Services	19	16
Other (e.g. maintenance and depreciation)	9	6

Table 7.2 Differences in production costs between milling and bakery businesses

7.3 Managing finances

Once a mill or bakery becomes operational, its continued success depends on achieving a sufficient profit after all bills have been paid. Achieving profitability depends on maintaining (or preferably increasing) income from sales while controlling (or preferably reducing) costs and maintaining a positive cash flow.

Profitability depends on having other aspects of the business operating successfully, such as marketing and sales (Chapter 2) and production planning (Chapter 6). Correct financial management involves:

• setting correct prices for products
• controlling costs
• managing cash flow
• accurate book-keeping.

Pricing products

The simplest way to work out the price for a product is to calculate the production costs and add a percentage for profit. In milling, product costing is relatively straightforward because:

• there is a limited number of raw materials
• the same production methods and equipment are used for all products, and hence production costs can be accurately calculated
• there is a limited range of packaging
• there is little variation in market prices for products.

However, there are often limited opportunities for millers to control the price that they charge for products, because of competition from other millers and, in some countries, government price control on flour. The main financial considerations in milling are therefore to reduce costs as much as possible (see below).

In bakeries, product costing is more complex because a wider range of ingredients is used. When a variety of products are produced, accurate costing enables the baker to find out which products are the most profitable and where expanded production would benefit the business. Accurate costing can also show which products are the most expensive to produce and where costs could be cut. This method of calculating the cost of a product (based on production costs) is straightforward and suitable for most millers and bakers. The profit margin that is added to the production costs is determined by the amount of competition, any government price controls and the demand for the product.

For some bakery products, especially celebration cakes or pastries, there may be fewer competitors and hence more flexibility for pricing. In this situation, the baker should decide the price that the market will bear, based on the quality of the products, among other factors. Research for this book indicated that affluent families in many ACP countries are willing to pay several hundred dollars for a high quality wedding or graduation cake. The cost of ingredients is not much higher than for other cakes, but the time and skill needed for the design and decoration to make a unique product allow the baker a mark-up of 200% or more. Unique or unusual pastries, breads etc. are likewise able to attract higher prices, provided there are affluent people willing to buy the goods and the products have a consistently high quality. This is one of the benefits of product diversification and development (Chapter 4).

Controlling costs

The main costs in milling are raw materials, labour and power charges. Of these, the raw material costs are the most important and these can be controlled in a number of ways:

- bulk purchase of grain during the harvest season when prices are lowest
- buying directly from farmers rather than from traders, preferably using a company-owned vehicle for transport
- fixing prices for grain through contracts with farmers
- price incentives to encourage farmers to supply high quality grain with minimal contamination (reducing processing costs and wastage at the mill).

Details of the required quality of grain and contract farming are given in Chapters 5 and 6 respectively. The effect of price variation in raw materials on profitability is shown in Table 7.3.

Cost (US$)	Effect of raw material price variation		Effect of plant utilisation	
	Harvest time	Out of season	Operating at 80% capacity	Operating at 50% capacity
Total fixed costs [1]	5000	5000	5000	5000
Variable costs				
Labour	1500	1500	1500	1500
Grain	11000	28000	11000	6875
Power	800	800	800	500
Total	18300	35300	18300	13875
Income	24600	24600	24600	15375
Profit	6300		6300	1500
Loss		10700		

[1] *Rent, utilities, taxes, maintenance etc.*

Table 7.3 Effects on profitability of buying crops out of season or operating a mill below capacity

7

Power consumption can be controlled by:

- ensuring that the grain is milled at its optimum moisture content (Chapter 5, Table 5.2) to maximise the efficiency of the mill
- ensuring that the mill is correctly set up and regularly maintained (Chapter 6, section 6.3)
- ensuring that machinery is switched off when not in use
- minimising re-processing due to damaged or broken grains.

The profitability of a mill also depends on the productivity of the workers and equipment. Wages and depreciation on machinery are fixed costs, and these cannot be covered by sales income if a mill operates at a small percentage of its capacity. Proper production planning to maximise output for a given number of workers and preventative maintenance to reduce machine downtime (Chapter 6, section 6.3) can both reduce production costs. The effect of operating below planned capacity on the profitability of a flour mill is shown in Table 7.3.

In bakeries, the main production costs are labour, fuel and ingredients. Where products such as biscuits require specialist packaging this can also be a significant cost. The main methods of cost control include:

- planning the work of production staff to ensure that they are fully occupied throughout the day, and training them to maximise their output and productivity
- selecting an oven that can operate using cheaper fuels
- maximising the use of heat in a fuel-fired oven by baking a sequence of products, or ensuring that a gas or electric oven is only heated when required
- creating or modifying recipes to reduce the amounts of expensive ingredients while maintaining the required quality
- reducing stocks of expensive ingredients or materials that are likely to deteriorate quickly and result in wastage
- keeping records of inputs and relating these to the amount of products that are sold
- looking for changes and trends in consumption.

Managing cash flow

Understanding how cash flows in and out of the business during a specified period (e.g. a month or a quarter) enables a miller or baker to ensure that there is always sufficient money to keep the business operating (i.e. maintain a positive cash flow). Cash flow can be managed by keeping control over the number of debtors and the amount of money that they owe a business, and by arranging with suppliers to have a larger credit limit or a longer period before payment. Examples of the ways in which small-scale millers and bakers have achieved this are described in Case study 7.2.

Case study 7.2 Managing debts

'We have a system where defaulters are given up to one month to pay and then we stop supplying them with goods. All customers have a ceiling so someone might owe us for several deliveries but not have hit their ceiling.'

'We have standard letters that we send out with the invoices if a payment is delayed. Then we follow this up with a polite phone call, and this has always worked miracles in debt recovery.'

'We only give seven days credit and we emphasise that payment should be in cash. We always take legal action against defaulters.'

'It is sometimes very difficult to recover outstanding debts from customers, particularly big government corporations, but regular follow-ups generally ensure that debts are recovered.'

'With debt recovery I am always firm. I go through the procedure of invoicing, reminding, and then send a final reminder. We never have to threaten anyone into paying up.'

'My biggest customers are schools and yet they are the biggest defaulters. I appreciate that their income is seasonal and so I am willing to wait. When I do get paid, I bank the money and use it for capital investment.'

Book-keeping

Accurate record keeping is needed to successfully price a product and to keep control over production costs and cash flow. To calculate the profitability of the business, a miller or baker also needs to know the level of assets in the business (e.g. cash, machinery, stocks of materials etc.) and any liabilities (loans, creditors, taxes owed etc.). These figures should be recorded using a balance sheet.

Common financial mistakes

Some of the areas where millers and bakers tend to go wrong are:

- treating profits as their income, instead of paying themselves a salary (the profits belong to the business and should be used to develop it)
- failing to cost and price products correctly, so they do not make a profit
- poor record keeping, so they do not know if they are operating profitably
- over-spending or having a loan that is not repayable
- having too many debtors or creditors.

Summary of the chapter

- ✔ Assess start-up costs and ensure that adequate finance is available before you start the business
- ✔ Do not rely solely on loans; have your own money too
- ✔ Assess all production costs (fixed and variable costs) to calculate prices for your products
- ✔ Manage your finances well and make sure you always have a positive cash flow
- ✔ Keep records so that you know the financial position of your business at any time
- ✔ Examine all costs and find ways to reduce them
- ✔ Do not treat profits as your income, they belong to the business
- ✔ Try hard to get prompt payment from customers

Entrepreneur’s checklist

- ❑ If you are starting a business, do you know what all the start-up costs will be?
- ❑ Do you have enough money or agreed loans or investment from backers?
- ❑ If your business is operating, do you know all your production costs?
- ❑ Do you record and use financial information to plan the next steps in developing your business?
- ❑ Have you examined different ways to reduce costs?
- ❑ Are the prices for your products competitive and high enough to make a profit?
- ❑ Do you know what your income is going to be this week and whether you will make a profit? If not, why not?

Readers' notes

Please use this space to make your own notes on Chapter 7.

7

Appendix I

The science of milling and baking: understanding the product and process

This section contains a summary of some of the important scientific aspects of milling and baking. Extra technical information is contained in 'Technical Boxes', which do not have to be read to understand the topic. For more detailed information, see the bibliography in Appendix III.

Milling

Cereal grains contain a complete embryo and all the structural components and enzyme systems needed for the growth of a new plant. Grains have four main parts: the tip cap which is the point of attachment to the stem or cob, the bran or protective outer covering, the germ or embryo which forms the new plant, and the endosperm – the reservoir of starch needed to support germination (see Fig. 3.5, page 60). It is the starchy endosperm that is used to make flour. The proportions of other parts of the grain that are retained in the flour are determined by the extraction rate (Chapter 4, section 4.3).

Grain storage and aflatoxins

After harvesting, cereals are normally dried in the field on earthen or concrete slabs, on roofs of buildings or on roads, which can result in contamination by insects, dirt, animal excreta etc. Inadequate capital and poor financial returns prevent farmers from investing in crop driers to minimise contamination. However, other low cost techniques, such as drying grain on raised platforms or covering with netting, provide adequate methods of reducing contamination by insects and birds. If farmers sell inadequately dried crops, there is a significant risk of mould growth, particularly in crops such as maize that are not shelled before drying. The mould grows out of sight under the shell and contaminates the grains. Certain species of moulds produce a range of poisons, collectively known as mycotoxins in cereals. Aflatoxins are the most common of these. The symptoms of poisoning include kidney and liver damage, cancer and bleeding in the brain and lungs. Mycotoxin contamination can be prevented if crops are dried sufficiently to prevent mould growth and then stored in structures that keep them dry.

Forces in milling

The milling process involves three types of forces:
- compression or squeezing forces
- impact or hitting forces
- shearing or rubbing forces.

Most mills use all three types, but generally one is more important than the others; for example, impact forces are more important in hammer mills and shearing forces are important in plate mills. When force is applied to a grain it causes the tissues to deform. If this does not exceed a certain critical level the tissues return to their original shape when the force is removed, and the stored energy is released as heat. However, when this level is exceeded, the grain fractures along a line of weakness. Part of the stored energy is then released as sound and heat. As little as 1% of the energy in a mill may actually be used for milling and the rest becomes heat and noise. As the sizes of the pieces reduce, there are fewer lines of weakness available. More force is needed to break the food and this requires additional energy. There is therefore a substantial increase in the amount of energy needed to produce smaller sized particles (or finer flours).

The amount of energy that is needed to break a food is determined by its hardness and its tendency to crack ('friability'). This in turn depends on the structure of the food and its moisture content. This is why grain is 'conditioned' to an optimum moisture content before milling to toughen the bran and soften the starchy endosperm. Some millers add an additional 0.5-1% water before milling to improve bran separation. Maize is thoroughly soaked before wet-milling to obtain complete disintegration of the starchy material. Further details are given in references in the bibliography; see Kent and Evers (1994) for grain characteristics and Fellows (1997/2000) for details of how to calculate the energy required for milling.

Maintaining a hammer mill

If a hammer mill fails to grind efficiently the hammers may be badly worn. The first step is to turn them around to use the second edge (Fig. A1). When the second edge is also worn, they 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 causing damage. 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.

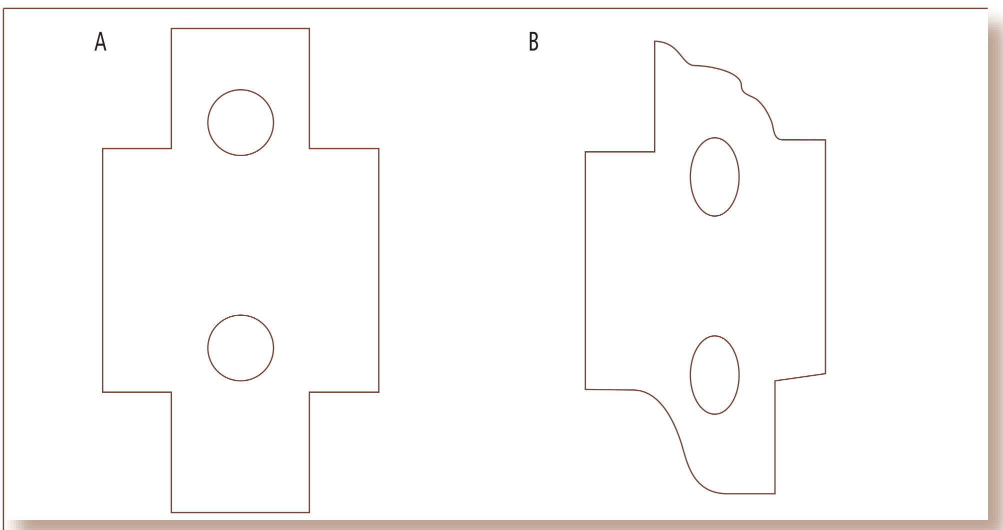

Fig. A1 (A) New hammer, (B) worn hammer from a hammer mill (P. Tibasiimwa)

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. A2).

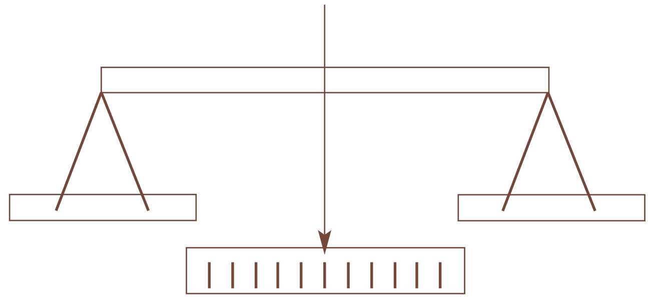

Fig. A2 Simple balance for checking the weight of hammers. The pointer should hang vertically when there are no hammers on the balance

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 weld and re-drilling them. The rotor must then be re-balanced. A simple way 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. The weight of the rotor at the top is then increased by dropping weld onto the outer edge.

Alignment of pulleys and V-belts

Mills and hullers are usually driven by belts connecting the motor to the mill. These come in five sizes (A to E), but 'B-section' or 'C-section' belts are most commonly used on small mills or hullers (Table A1). Pulleys and belts should be as short as possible and should be 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 set at exactly 90° 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 16 mm 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 to tension belts correctly. Dust is one of the main causes of damage to V-belts and they should therefore be cleaned daily.

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, 1 HP = 0.745 kW. Minimum 'B' pulley diameter = 115 mm, minimum 'C' pulley diameter = 175 mm.

Table A1 Number of belts required for mills of different power

Checking the operation of a mill

A supply of good quality grain is important if operating costs of the mill are to be reduced. Properly dried and cleaned grain mills faster, requires less energy (therefore uses less power) and creates less wear on the mill and huller (reducing 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 mill to cyclone
- correct design of cyclone.

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 will be 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 A2 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 using the following formula:

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

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.

Table A2 Optimum rotor speeds for different sized hammers in a hammer mill

Fan and cyclone separator

The correct designs for these components are described in Chapter 3 (section 3.2).

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 identify the cause. For example if a blown fuse is the problem, but bare wires touching the roof is the cause, no matter how many times you replace the fuse it will not stop the wires touching the roof. Some examples of faults in a hammer mill and possible causes are given in Table A3. Similar considerations apply to other types of milling equipment.

Fault	Check
Motor stops running	• where there is more than one machine, check the other to see if it is working • if neighbours' machines are working • if power is there at the correct voltage • for a burning 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
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

Fault	Check
Motor smoking	• if varnish on motor windings is intact • for worn bearings • starter • for loose connections • for burnt out motor
Motor over-heating	• bearings • 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 (are 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 unaligned • 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

Table A3 Checking for faults in milling equipment

Components of flour

Proteins

Proteins are chemicals made from long chains of amino acids linked together. Different combinations of amino acids produce different types of proteins. Amino acids are also important because they react with sugars to create brown coloured chemicals and aroma chemicals (see Technical Box 3 on page 230).

Gluten is a protein that is present as tightly coiled 'springs' in wheat flour. When moistened and warmed, the springs uncoil and the amino acids along the protein chains react and bond the different chains together, forming a network or lattice. It is this lattice structure that contains the starch granules and gives the characteristic crumb structure to bakery products.

Sugars

There are many different types of sugars, in addition to the one that most people know (sucrose). The starch in flour is made up of long chains of different sugars. Natural enzymes in cereal grains (named amylases) are able to break down the chains into smaller units (named dextrins), or after further breakdown, into the component sugars. This enzyme activity takes place when a grain germinates and also when flour is moistened and warmed during dough preparation. The small amounts of naturally occurring sugars in flour and added sucrose are used by yeast to produce carbon dioxide.

Sugars make bakery products sweeter, and also react with amino acids when heated during baking, to form colour and aroma chemicals. Dextrins have a binding and thickening action in the dough and therefore help to form the structure and texture of bakery products.

Baking

In bread-making, the aim is for the dough to be sufficiently extensible to expand when it is baked in the oven, but also to retain the gas formed by the yeast and produce a porous crumb. There is thus a relationship between the balance of ingredients and the time and temperature of the dough fermentation. If the fermentation time is increased, the amount of yeast and water should be reduced and the salt content increased – thus slowing the rate of fermentation and increasing the strength of the gluten. Longer fermentation times also allow the dough to ripen to a greater extent. With too little salt, the sugars break down more extensively to form gas, and because the gluten structure is weaker, there is more rapid and greater expansion of the dough. This creates an over-large loaf, an insipid flavour and a loose crumb structure. Dough without any salt will have very rapid fermentation and expansion in volume leading to a risk of collapse. As the salt content is increased in a recipe, the rate of fermentation is slowed because the yeast activity is reduced and less gas is produced. This, together with the toughening effect on the gluten, results in progressively smaller loaves until a dark, heavy, rubber-like mass is produced with an overly salty flavour.

The main purpose of baking is to alter the eating quality of foods (the texture, flavour and colour). A secondary purpose is to preserve the food, using heat to destroy micro-organisms and reduce the moisture content (Technical Box 1) which in turn prevents re-contamination by moulds or bacteria.

Technical Box 1 Moisture content

Water in a food exerts a 'vapour pressure'. The size of the vapour pressure depends on the amount of water present, the temperature, and the amount of salt and sugar in the food. When dough is placed in a hot oven, the low humidity of the air in the oven creates a moisture vapour pressure gradient. This causes moisture at the surface of the food to evaporate, and moisture to move from inside the food to the surface. When the rate at which moisture is lost from the surface becomes greater than the rate at which it moves from the interior, the surface dries out, its temperature rises to the temperature of the oven, and a crust is formed. Because baking takes place at atmospheric pressure and moisture escapes freely from the food, the internal temperature of the food does not rise above 100°C. Further details can be found in sources in the bibliography.

The extent to which a product is dried depends on the type of product and the baking conditions. Biscuits, for example, have a dry crust and a dry crumb, whereas bread and cakes have a dry crust and moist crumb. The shelf life of bakery products is determined mostly by their moisture content and the conditions under which they are stored. Products that have a moist crumb have a shorter shelf life unless they are protected by packaging, or a dry coating of marzipan and icing, or stored in a refrigerator or freezer.

Types of heat

There are three types of heat produced during baking (Technical Box 2):

- radiation from the oven walls, which is absorbed into the food and causes it to heat up
- convection from hot air circulating in the oven
- conduction through the baking tin or tray.

Technical Box 2 Types of heat

Radiation is the transfer of heat by electromagnetic waves (e.g. in an electric grill).
Conduction is the direct movement of heat energy within solids (e.g. through metal containers or solid foods).
Convection is the transfer of heat by molecules that move because of differences in their density (e.g. in heated air) or because they are moved by a machine (e.g. a stirrer in liquids or a fan moving air).
In most ovens all three types of heating take place together, but in some designs one type may be more important.

A 'boundary film' of air around the food slows down both the rate at which heat is transferred into the food, and the movement of water vapour out of the food. The thickness of this boundary layer depends on the speed at which the air moves inside the oven and whether the surface of the food is rough or smooth. Many commercial ovens are fitted with fans to reduce the thickness of boundary films and heat food more quickly. The fans also produce more uniform heating throughout the oven.

Most bakery products are heated internally by conduction, but there are convection currents in cake batters during the initial stages of heating. The distance that the heat must travel to bake the centre of the food, and the time that this takes, depend on the composition of the dough and the size of the pieces of food. It is therefore important to make sure that pieces of dough are formed to the same size to ensure that they all are thoroughly baked to the centre at a particular baking time and temperature. If the size of pieces varies, some will be under-baked and others will be burned.

Effects of baking

The rapid heating and high temperatures used in baking cause complex changes, especially to the surface of the product. These changes alter the flavour, colour and texture of the food.

In the surface layers of dough, caramelisation of sugars, non-enzymic or 'Maillard' browning reactions between sugars and amino acids (Technical Box 3), and changes to fats each take place during baking. These reactions produce a very large number of aroma chemicals that give the characteristic smell of freshly baked bread, cakes etc. The aroma of a particular baked product depends on the combination of fats, amino acids and sugars in the dough, and hence on the mixture of ingredients used.

Technical Box 3 Non-enzymic browning

The Maillard reaction between amino acids and sugars that are present in dough causes browning and produces different aromas. Depending on the heating conditions, a particular sugar and amino acid react to produce a specific aldehyde that has a characteristic aroma (e.g. the amino acid proline can produce aromas of potato, mushroom or burnt egg when heated with different sugars and at different temperatures). Further heating breaks down some of the aroma chemicals to produce burnt or smoky aromas.

Changes in texture depend on the ingredients used in the dough, its moisture content and the temperature and time of baking. In bread, gelatinisation and changes to the structure of starch, together with loss of moisture, produce the characteristic texture of the crust. In steam heated ovens, there is less drying of the dough surface. The crust therefore remains elastic for longer and the dough expands more fully. The crust is smoother and glossier, and Maillard browning reactions give a darker crust colour. During storage of bread or cakes, moisture moves from the crumb to soften the crust. Slower heating allows more moisture to escape before the surface is sealed by the crust, resulting in a drier crumb with a longer shelf life (e.g. biscuits).

The characteristic golden brown colour of baked foods is due to Maillard browning, caramelisation of sugars to form brown pigments, and carbonisation of sugars, fats and proteins. The glaze is due to caramelisation, which occurs when the oven humidity is high. Under-ripe dough, which contains a fairly high sugar content, will give a high crust colour, while over-ripe dough gives a pale crust colour. The natural enzyme activity in flour also affects the amount of sugar present in the dough and hence the colour of the crust.

Nutritional value

Some baked foods comprise a significant part of the diet in many developing countries and are therefore an important source of proteins, vitamins and minerals. Others (e.g. biscuits, pastries, cakes and snackfoods) make up only a small part of the diet, and nutritional losses are less significant. The main nutritional changes occurring during baking take place on the surface. With the exception of vitamin C (ascorbic acid), which is sometimes added to bread dough as an improver and is destroyed during baking, vitamin losses are relatively small. In chemically leavened doughs, the alkaline conditions actually improve absorption of the vitamin niacin, while the fermentation of bread dough adds B vitamins. Thiamine is the most important vitamin in cereal foods that is destroyed by heat. The temperature of baking and the type of dough determine the level of thiamine loss. In bread it is approximately 15%, whereas in cakes or biscuits that are leavened by sodium bicarbonate, the losses increase to 50–95%. During baking, the nutritional value of proteins and fats is not significantly affected, although the loss of amino acids and sugars in Maillard browning causes a small reduction in nutritive value. Higher temperatures and longer baking times increase the losses. Further information on nutritional aspects of bakery products can be found in references in the bibliography.

Staling

Staling is not caused by bakery products drying out, but is produced by slow changes to the starch in the crumb and crust (termed retrogradation). The starch changes from an amorphous form to a crystalline form and this results in:

- toughening of the crust
- firming of the crumb
- loss of flavour
- movement of moisture from the crumb to the crust
- shrinking of starch granules away from the gluten 'skeleton' leading to a crumbly loaf.

The rate of staling depends on the temperature of storage and is highest at around 4°C (Fig. A3), which is close to the temperature in a refrigerator. It is lowest at freezer temperatures (around –18°C) and above 50°C. Bakery products should not therefore be stored in a refrigerator unless they contain cream, meat or other ingredients that are likely to cause food poisoning, but freezing is acceptable to extend their shelf life.

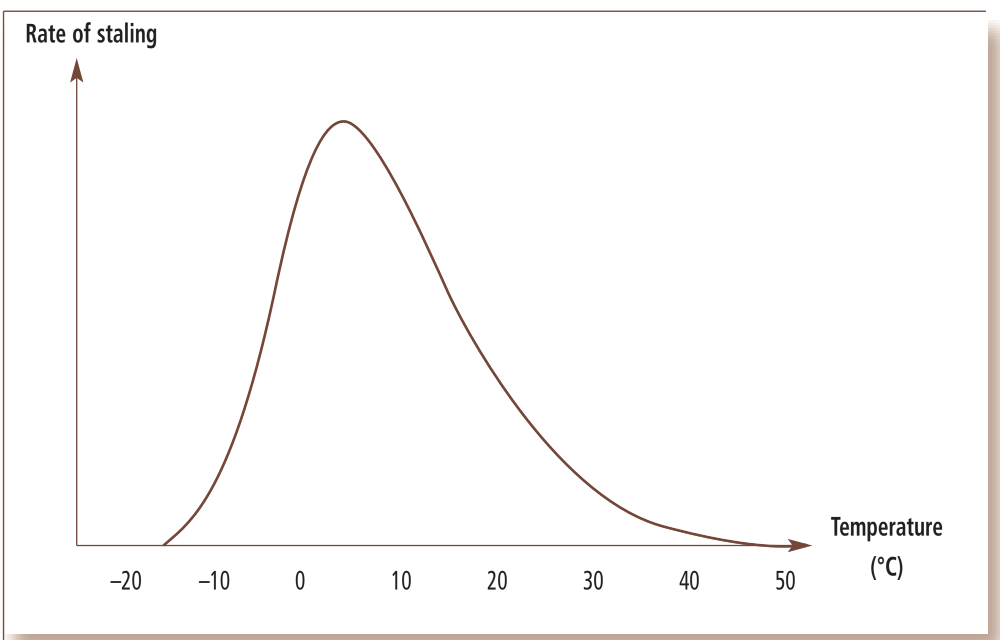

Fig. A3 Rate of staling at different storage temperatures

Appendix II

Institutions offering support to small-scale millers or bakers

Institutions that provide support to small-scale food processors are listed in Volume 1: *Setting up and running a small food business.* The following additional institutions are able to provide information. Those that are marked with an asterisk are able to answer technical enquiries on milling or baking.

* **Agromisa Foundation**, PO Box 41, 6700 AA Wageningen, The Netherlands.
Tel/Fax: 31 317 412217 / 419178,
E-mail: agromisa@agromisa.org,
Web: www.agromisa.org

APICA Ensia-Siarc, BP 5098, 34033 Montpellier Cedex 01, France.
Fax: 33 (0)4 67 61 70 55,
E-mail: giroux@cirad.fr

Centre for the Development of Enterprise (CDE), Avenue Herrmann Debroux 52. B1160 Brussels, Belgium.
Tel: 32 2 679 18 11, Fax: 32 2 675 19 03,
E-mail info@cdi.be, Web: www.cdi.be.
(CDE has a network of associated organisations in ACP countries)

Deutsche Gesellschaft für Technische Zusammenarbeit (GTZ) GmbH, Dag-Hammarskjöld-Weg 1–5, 65760 Eschborn, Germany.
Tel: 49 (0)6196 79 0, Fax: 49 (0)6196 79 1115,
E-mail: gtz@gtz.org.ge, Web: www.gtz.de

Enterprise Works, 1828 L Street NW, Suite 1000, Washington, DC 20036, USA.
Tel: 1 202 293 4600, Fax: 1 202 293 4598,
E-mail: info@enterpriseworks.org,
Web: www.enterpriseworks.org

* **GRET**, 211–213 rue La Fayette, 75 010 Paris, France.
Tel: (33) 1 40 05 61 61,
Fax: (33) 1 40 05 61 10,
E-mail: gret@gret.org,
Web: www.gret.org

* **Intermediate Technology Development Group (ITDG), The Schumacher Centre for Technology & Development**, Bourton Hall, Bourton-on-Dunsmore, Rugby, CV23 9QZ, UK.
Tel: 44 1926 634400,
Fax: 44 1926 63440,
E-mail: itdg@itdg.org.uk, Web: www.itdg.org

International Development Research Centre (IDRC), PO Box 8500, Ottawa, Ontario, Canada, K1G 3H9.
Tel: 1 613 236 6163,
Fax: 1 613 563 2476,
E-mail: pub@idrc.ca,
Web: www.idrc.ca

ITDG Publishing, 103–105 Southampton Row, London,
WC1B 4HL, UK.
Tel: 44(0)20 7436 9761,
Fax: 44(0)20 7436 2013,
E-mail: itpubs@itpubs.org.uk,
Web: www.itpubs.org.uk,
www.developmentbookshop.co.uk

Royal Tropical Institute (KIT) Publishers,
PO Box 95001, 1090 HA Amsterdam,
The Netherlands.
Tel: 31 20 5688 272, Fax: 31 20 5688 286,
E-mail: publishers@kit.nl,
Web: www.kit.nl

*** Strengthening African Food Processing Project (SAFPP)**,
CSIR Bio/Chemtek-FFD, Building 22, PO Box 395, Pretoria, South Africa
Tel: 27 12 841 3097,
Fax: 27 12 841 3726,
E-mail: dharcourt@csir.co.za,
Web: www.safpp.co.za

Technical Centre for Agricultural and Rural Cooperation ACP-EU (CTA), Postbus 380,
6700 AJ Wageningen, The Netherlands.
Tel: 00 31 317 46710000,
Fax: 31 317 460067,
E-mail: @cta.nl, Web: www.agricta.org.
(CTA has a network of associated organisations in ACP countries)

United Nations Industrial Development Organization (UNIDO), Vienna International Centre, PO Box 300, A-1400 Vienna, Austria.
Tel: 43 1 26026, Fax: 43 1 2692669,
E-mail: unido@unido.org, Web: www.unido.org

Organisations with specific areas of expertise in cereal processing, bakery or which offer support to small-scale bakers or millers:

American Association of Cereal Chemists (AACC), 3340 Pilot Knob Road, St. Paul, MN 55121-2097, USA.
Tel: 1 651 454 7250, Fax: 1 651 454 0766,
E-mail: aacc@scisoc.org

Arusha Hotel Training Institute, Nairobi Road, Arusha, Tanzania.
Tel: 255 27 2508913,
Fax: 255 27 2548879,
E-mail: ahti@habari.co.tz

Campden and Chorleywood Food Research Association, Chipping Campden, Gloucestershire, GL55 6LD, UK.
Tel: 44 1386 842000,
Fax: 44 1386 842100,
E-mail: information@campden.co.uk,
Web: www.campden.co.uk

CIRAD Agrifood Systems Programme, 73 rue Jean-François Breton, TA 40/16, 34398 Montpellier Cedex 5, France.
E-mail: paa@cirad.fr, Web: www.cirad.fr

Eastern and Southern Africa Regional Center (IITA-ESARC), Namulonge, PO Box 7878, Kampala, Uganda.
Tel: 256 41 223460, Fax: 256 41 223459,
E-mail: IITA-Uganda@cgiar.org

Food and Agriculture Organization (FAO),
Viale delle Terme di Caracalla, 00100 Rome, Italy.
Tel: 39 06 5705 1,
Fax: 39 06 5705 3152,
E-mail: fao@fao.org.
There is a large website, with many links and free information, including equipment suppliers at www.fao.org/inpho
and publications at
www.fao.org/CATALOG/GIPHOME.HTM or
www.fao.org/docrep

Food Research Institute, PO Box 43, Accra, Ghana. Tel: 233 21 7776897
Headquarters: IITA Benin Research Station, BP 08-0932, Cotonou, Benin.
Tel: 229 350553, 350186, 350600, 350601, 350188, Fax: 229 350556,
E-mail: IITA-Benin@cgiar.org

IITA Savanna Station, c/o WARDA/ADRAO, 01 BP 2551, Bouaké 01, Côte d'Ivoire.
Tel: 225 31634514, Fax: 225 31634714,
E-mail: WARDA@cgiar.org

International Institute for Tropical Agriculture (IITA) c/o Lambourn (UK) Limited, Carolyn House, 26 Dingwall Road, Croydon CR9 3EE, UK.
Tel: (44) 020 8686 9031,
Fax: (44) 020 8681 8583

National Institute for Scientific and Industrial Research, Food Technology Research Unit, Airport Road, PO Box 310258, Lusaka, Zambia.
Tel: 260 1 282488 or 260 1 282081–4,
Email: nisiris@zamnet.zm

Natural Resources Institute (NRI), Medway University Campus, Central Avenue, Chatham Maritime, Kent, ME4 4TB, UK.
Tel: 44 (0)1634 880088,
Fax: 44 (0)1634 880066/77,
Email: nri@greenwich.ac.uk,
Web: www.nri.org

Nyati Baking Academy, 493A Kafue Road, PO Box 33063, Lusaka, Zambia.
Tel: 260 (0) 97 770287
PMB 5320, Ibadan, Oyo State, Nigeria.
Tel: 234 2 241 2626,
Fax: 234 2 241 2221,
E-mail: IITA@cgiar.org

Regional offices dealing with cereal crops/products:

SADC/IITA/SARRNET Mikocheni Research Station, PO Box 2066, Dar es Salaam, Tanzania.
Tel: 255 51 811 700986, Fax: 255 51 112501,
E-mail: SARRNET@cats-net.com

SADC/IITA/SARRNET, Paul Gatrell Building, Off Chilambula Road, PO Box 30258, Lilongwe 3, Malawi.
Tel: 265 744205, 744440, Fax: 265 782835,
E-mail: sarrnet@malawi.net

SADC/IITA/SARRNET/INIA, FPLM Malvane, CP 2100, Maputo, Mozambique.
Tel: 258 1 460097, 491767,
Fax: 258 1 460074, 491767,
E-mail: mandrade@zebra.uem

Tanzania Traditional Energy Development and Environment Organization (TATEDO), PO Box 32794, Dar es Salaam, Tanzania.
Tel: 255 22 274400/700771,
Fax: 255 22 274400,
E-mail: tatedo@raha.com

Organisations dealing with legal standards:

Secretariat of the Joint FAO/WHO Food Standards Programme, Food and Agriculture Organization of the United Nations (FAO), Viale delle Terme di Caracalla, 00100 Rome, Italy.
Tel: 39 06 5705 1, Fax: 39 06 5705 4593,
E-mail: codex@fao.org,
Web: www.codexalimentarius.net

United Nations Committee on Trade and Development (UNCTAD), External Relations and Communications, Palais des Nations, 1211 Geneva 10, Switzerland.
Tel: 4122 907 1234,
Fax: 4122 907 0043,
E-mail: ers@unctad.org, Web: www.unctad.org.

The following organisations have information on management and health and safety issues:

International Labour Office (ILO), Communications and Files Section (DOSCOM) 4, route des Morillons, CH-1211 Geneva 22, Switzerland.
Tel: 41 22 799 6111, Fax: 41 22 798 8685,
E-mail: ilo@ilo.org

Publications (PUBL):
Tel: 41 22 799 7866, Fax: 41 22 799 6117,
E-mail: publns@ilo.org

Library and Information Services (BIBL):
Tel: 41 22 799 8675, Fax: 41 22 799 6516,
E-mail: bibl@ilo.org

InFocus Programme on Boosting Employment through Small Enterprise Development (IFP/SEED):
Tel: 41 22 799 6862, Fax: 41 22 799 7978,
E-mail: ifp-sed@ilo.org

Appendix III

Further reading and bibliography

References used in the text

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Milling

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Small-scale food processing sector in Mozambique
Small-scale food processing sector in South Africa
Small-scale food processing sector in Zambia, each by Imani Development (pvt) Ltd in collaboration with O. Saasa, 2000. Technical Centre for Agricultural and Rural Co-operation (CTA), Wageningen, The Netherlands.

CTA also distributes the Agrodok series of books. In particular:
Agrodok No. 13: Protection of stored cereal grains and pulses
Agrodok No. 22: Small scale production of weaning foods
Agrodok No. 25: Granaries
Agrodok No. 26: Marketing for Small-scale Producers.

For producers who can obtain assistance from a small business advisory service or an international development agency with access to the Internet, there are a large number of websites on baking or milling. Many are commercial sites that sell equipment or ingredients, but some give recipes and information on how to make bakery products. The following websites have useful information and good links to other sites:

www.bakery-net.com (buyer's guide, bookstore, links to other associations)
www.preparedfoods.com (ingredients and recipes from magazine articles)

FAO has a number of links to relevant sites:

Agricultural Research Information System (AGRIS). www.fao.org/agris
Agricultural Network Information Center. Includes AGRICOLA (AGRICultural On-Line Access). www.agnic.org
FAO Catalogue on-line. Some with links to full text. www.fao.org/info
CAB International Abstracts CDs. www.cabi.org
International Network for the Availability of Scientific Publications. www.inasp.org.uk
IDRC Books. www.idrc.ca/books
FAO World Agricultural Information Centre (WAICENT). www.fao.org/waicent

The following provide direct links to pages within the WAICENT site:

FAOSTAT, a wealth of statistical data on many agro-related topics. http://apps.fao.org
Information Network on Postharvest Operations (INPHO). www.fao.org/inpho
SCIRUS – for scientific information only. www.scirus.com
AGRALIN, Information sources in agriculture and related fields. www.agralin.nl/desktop
Technical Centre for Agricultural and Rural Cooperation (CTA). www.agricta.org
Network of European Tropically and Subtropically Oriented Agricultural Universities (NATURA). www.natura.agropolis.fr
Global Forum on Agricultural Research. Information exchange and communication between national agricultural research systems, advanced research institutes, non-government organisations and international agricultural research organisations. www.egfar.org
Pesticide information site for Africa (in French). www.isysphyt.ci.refer.org
Association of African Universities www.aau.org

Glossary and acronyms

Term	*Definition*
Absorption	The soaking up of one substance into another. Usually refers to water used to form a dough with a particular flour
Additives	Any small amount of a recipe other than the main ingredients
Aerate	To fill with gas (in baking this usually refers to air or carbon dioxide)
Albumen	A protein found in egg white
Aflatoxins	Poisons produced by certain types of moulds in cereals, nuts etc.
Arabic	Dried gum of the Acacia tree
Bag	1) Imperial measure of flour (140 lb = 63.5 kg) 2) A cone made from paper, cloth or plastic used to apply icing in cake decoration
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
Baking sheet	Metal tray on which bread and other bakery products are baked
Batter	Unbaked cake mixture
Beat	To mix ingredients rapidly to form a cream or paste
Blades	The parts of a mechanical mixer that move and mix ingredients
Blend	To mix ingredients together
Blind (baking)	To bake a pastry case without a filling
Bloom	Bright tints of colour on the crust of baked products, produced by caramelisation of sugars

Brake	Mechanical roller used to roll out pastry or biscuit dough
Bran	The layer of material below the outer hull of grains and the germ
Brioche	A sweet bread made in a fancy shape
Bun wash	A liquid brushed onto the surface of a bun after baking to produce a glaze
Cake hoop	A metal ring in which cake batter is baked
Candied	Preserved by soaking in concentrated sugar syrup
Caramel	Amber to brown solid or liquid produced by heating sugar
Caramelisation	The process of producing caramel
Carbon dioxide	The gas produced by yeast and chemical aerating agents in bakery products
Carboxy-methyl cellulose	A synthetic cellulose gum used as a stabiliser and thickener
Cell	1) An enclosed cavity as in gas or air contained in the crumb of bakery products 2) The structure of living organisms
Celsius	Centigrade scale of temperature measurement
Coagulate	Making a suspension of proteins solid or partially solid
Coat	To cover with (e.g. icing, chocolate etc.)
Compound fat	White fat made from hydrogenated vegetable oils
Conduction	Movement of heat through solid materials
Convection	Movement of heat through liquids or gases
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
Diastatic malt	Malt that has natural enzyme activity and causes breakdown of starch and dextrins to form sugars
Dextrins	Gums formed by the partial breakdown of starch, used as binders, stabilisers and thickeners
Dough	A mixture of flour and water
Egg wash	A mixture of egg and water used to produce a glaze on bakery products

Emulsifying agent	A chemical that stabilises an emulsion and prevents it separating into its component parts
Enrobe	To coat (e.g. with chocolate)
Ferment	1) To produce carbon dioxide and alcohol (by the action of yeast) 2) A fermented mixture prior to being made into dough
Final prove	The stage between final moulding and baking
Flan	Open pastry case with a filling
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
Glaze	To coat with a material that produces a shiny surface
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
Hydrogenation	The process used to convert liquid oils into solid fats
Hygroscopic	Able to absorb moisture
Icing	A sugar based coating or decorative material
Icing sugar	Finely powdered sugar
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
Large scale processing	A business having more than 50 employees, and capital more than US$1,000,000
Lecithin	A type of emulsifying agent extracted from soyabeans and other plants
Major Factor	Method used to calculate the temperature of water in dough making
Maltose value	A figure to represent the amount of sugars in flour

Marzipan	A paste made from sugar and almonds
Medium scale processing	A business having 16–50 employees, and capital of US$50,000–1,000,000
Micro scale processing	A business having fewer than five employees and capital of less than $1000
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
Mould	1) To form dough into a shape 2) A type of micro-organism 3) A hollow shape
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
Patent	Term used to describe grade of flour
Peaked	A cake fault comprising a cracked peak on the top
Peel	A flat long-handled shovel used to remove products from an oven
Petits fours	Very small fancy cakes
Pinning	Rolling out with a rolling pin
Piping	Forcing icing from a bag to decorate cakes etc.
Prove	Aeration of dough by yeast
Prover	Cabinet in which fermented doughs are proved before baking
Radiation	Transfer of heat by electromagnetic waves
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
Scaling	Weighing
Shortcrust	A type of easily broken pastry
Shortening	Bakery fat
Skinning	Formation of a surface crust on dough or egg white when left uncovered

Small-scale processing	A business having five to 15 employees, and capital of US$1000–50,000
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
Sponge	1) Thin batter that is fermented and then made into a dough by adding more flour 2) A mixture of egg and sugar that is beaten to a stiff foam and flour added
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

Acronyms

ACP	Africa, Caribbean, Pacific
CDE	ACP-EU Centre for the Development of Enterprise
CTA	ACP-EU Technical Centre for Agricultural and Rural Cooperation
DE	dextrose equivalent
FAO	Food and Agriculture Organization of the United Nations
FDA	Food and Drug Administration of the USA
FIFO	‘first in first out’ system
KNUST	Kwame Nkrumah University of Science and Technology
QA	quality assurance
UNCTAD	United Nations Committee on Trade and Development
UNESCO	United Nations Educational, Scientific and Cultural Organisation
USP	unique selling point

Index

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