PRACTICAL ACTION
Technology challenging poverty

BAKING

Baking is the process that uses an oven or hotplate to cook a wide range of flour-based foods. The main purpose is to produce products that have characteristic flavours, aromas, shapes, sizes, colours and textures. The secondary purpose is to preserve the food by controlling the moisture content and destroying enzymes or contaminating micro-organisms to extend the shelf life. There is a huge range of bakery products as a result of combining a wide variety of ingredients and using different baking techniques and conditions to produce the different products (Figure 1).

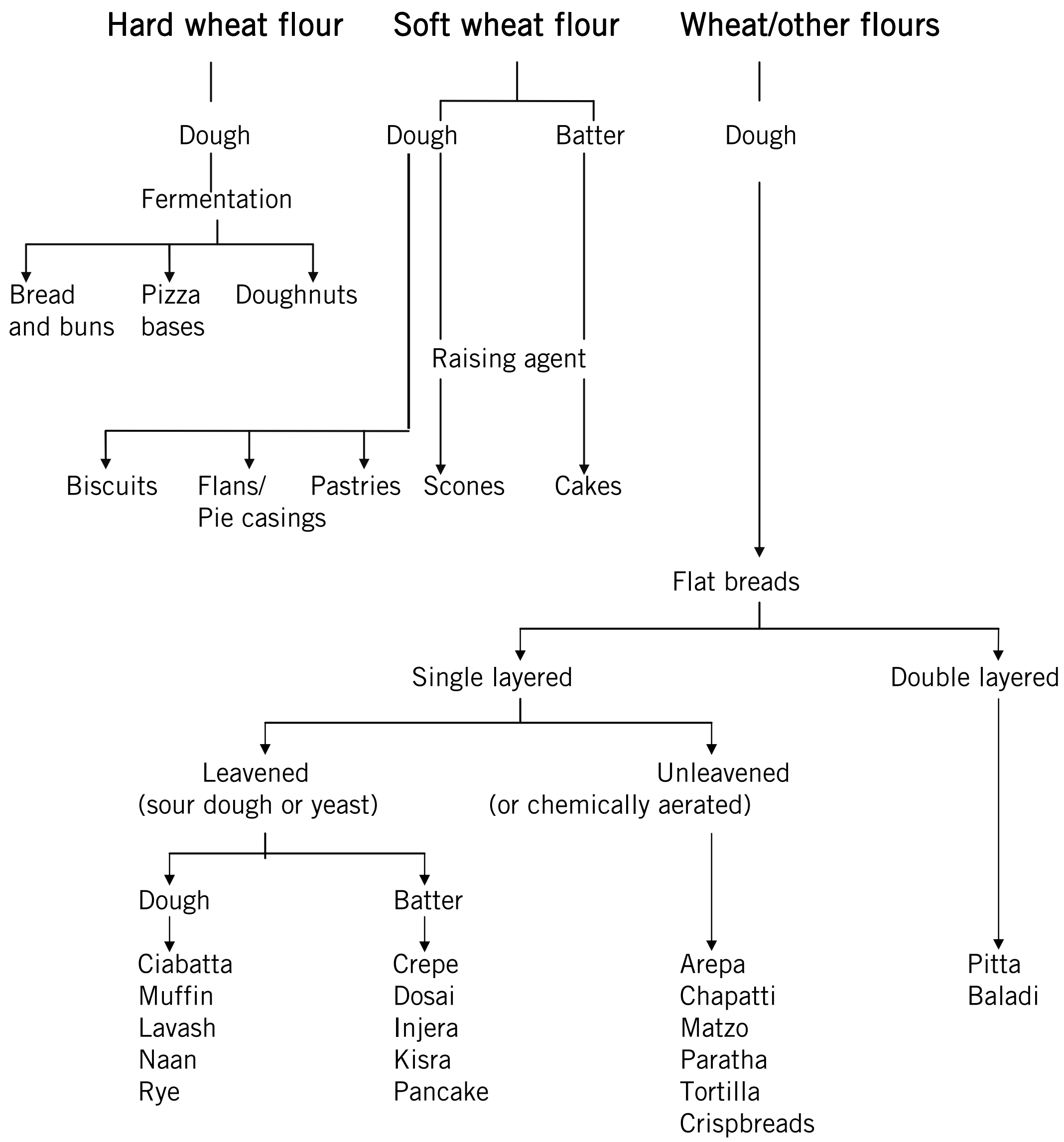

Figure 1: Types of baked cereal products (from Fellows and Axtell, 2004)

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technical brief

Baking therefore offers the opportunity for small-scale processors to add considerable value to basic ingredients using relatively inexpensive equipment, and as a result it is a popular and potentially profitable business in nearly all countries.

The quality of bakery products is the most important factor to ensure consumer acceptance and small differences in the aroma, colour, taste, texture and appearance of a product can result in success or failure. The characteristic aromas produced by baking depend on the temperature of baking and the composition of the ingredients, particularly the moisture content and the different types and amounts of fats, amino acids and sugars, which react together at high temperatures (known as 'Maillard' reactions). Other reactions that produce aromas are caramelisation of sugars and localised over-heating that produces burnt or smoky aromas. The golden brown colour associated with baked foods is also due to reactions between amino acids and sugars and the caramelisation of sugars. The taste (sweetness, saltiness) of bakery products is due to the amounts of sugar and salt that are added as ingredients. The characteristic textures of different bakery products is mostly due to the amount of starch gelatinisation in the flour: for example, partly gelatinised starch is found in products such as shortbread and the crumb in bread, whereas fully gelatinised starch produces the harder texture found in crackers. Raising agents (yeast or sodium bicarbonate) are also used also produce different textures in bakery products.

The baking process
Baking is one stage (or unit operation) in the process of making the products shown in Figure 1. It is preceded by other stages, such as cleaning and sorting grains, milling flours, weighing and mixing ingredients, fermentation for some products, and forming doughs. After baking, some products may be sliced, but are otherwise ready for sale without further processing. The stages used in a bakery to produce different products are described below, followed by simple methods of quality assurance. Further information on fermentation is given in Technical Brief: Fermented Foods, and information on milling is given in further information at the end of this technical brief.

Equipment
The basic equipment used in even the smallest bakery includes a range of utensils (Table 1), a mixer, an oven and/or hotplate, and a prover for leavened products (see Technical Brief: Food Fermentation).

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
Bowls	Plastic, aluminium or stainless steel, for mixing ingredients
Bread tins	Single tins of various sizes for different sized loaves, or 'straps' of 3-6 tins joined together. Special shaped tins for speciality breads
Bread slicer	For cutting bread into slices of uniform thickness
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
Flour sieve	Wire or nylon mesh to remove large particles from flour
Glaze brushes	For brushing on milk or egg to give a glossy surface to products
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
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
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
Spatulas	For stirring or beating ingredients
Storage bins	For bulk ingredients, baskets/trays for distribution of bakery products
Thermometer	For testing dough temperature or oven temperature. Special sugar thermometer for testing the temperature when making sugar confectionery
Whisks	For beating batters

Table 1: Small items of bakery equipment (Adapted from Fellows and Axtell, 2004)

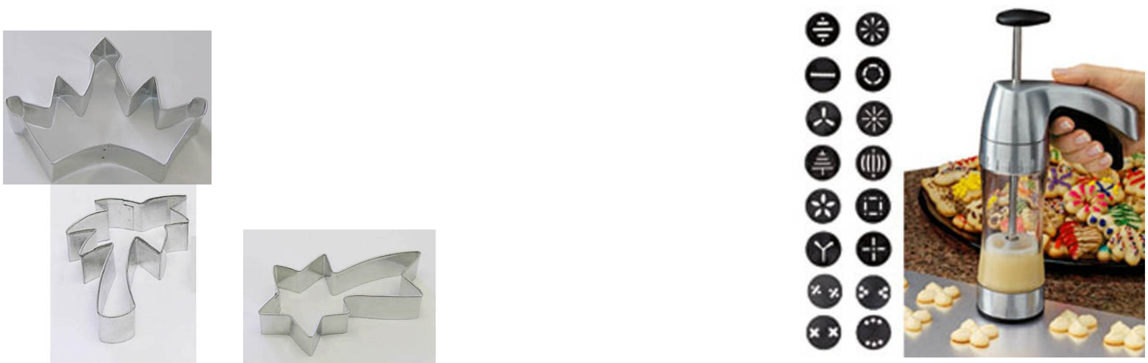
Mixers

Mixing is laborious and time-consuming, especially when preparing thick batters and doughs, and electric mixers are used whenever they are affordable. At household- and micro-scales of production it may be possible to use domestic mixers that are similar in operation to planetary mixers (below), but they are not designed for lengthy periods of continuous use and may need regular replacement of drive shaft pins or other components. All mixers are potentially dangerous and should be fitted with covers or grilles to prevent operators putting their hands into the mixing bowl when the mixer is operating. They should also have fail-safe devices such as an electric interlock to stop the machine operating if the cover is opened or not properly secured. Planetary mixers (Figure 2) are commonly used in small-scale bakeries. They are fitted with either gate blades for mixing thick cake batters, hooks for mixing doughs, or whisks to prepare thin batters or cake fillings such as whipped cream.

Figure 2: Planetary mixer for use in a bakery. Photo: Pete Fellows.

Forming pieces

In small-scale bakeries, dough for flat breads, such as chapatti, naan, paratha and tortilla, is rolled by hand with a rolling pin to form the required shape, thickness and size. Batters for flat products such as crêpes, injera and pancakes are poured in a thin layer and both types of products are baked using a hotplate. Other types of doughs and pastries (e.g. for bread, pies, samosas etc. are also formed by hand, but this is time-consuming and can also produce variable thickness in pieces if staff are not properly trained. To overcome these problems, rolling bars may be used to roll out the dough, and dough may be cut and shaped into uniformly sized pieces using a variety of manual or powered equipment. Rolling bars are strips of metal that have the same thickness as that required in the sheet of dough: two bars are placed either side of the dough and support a rolling pin so that it reduces the dough to the same thickness every time. For example, biscuits need to be the same size and thickness so that they bake to a uniform colour and texture, and there are a large number of hand-operated biscuit cutters (Figure 3a) that produce different shapes by pressing them into a sheet of biscuit dough that is rolled to uniform thickness. Alternatively, biscuit dough may be formed into different shapes using a cookie press (Figure 3b).



a) b)

Figure 3 a) Biscuit cutters, b) cookie press (The Bakers' Kitchen at www.thebakerskitchen.net).

At a larger scale of operation, machines are used to form biscuit dough using one of four methods: 1) a die forming machine has a metal roller with shaped cavities: a sheet of dough is pressed into the cavities and the excess is scraped away to leave the shaped biscuit dough; 2) two cutting rollers cut shapes from a sheet of dough and simultaneously imprint a design on the upper surface using raised characters on the rollers; 3) a 'wire-cut' machine extrudes soft dough through dies, and wires cut the dough into the correct lengths; 4) a 'rout press' (similar to a wire-cut machine but without the cutting wires) cuts extruded dough to the required length using a reciprocating blade. These machines are considerably more expensive than the manual equipment and are suited to larger scale bakeries.

Pie and tart cases are formed from sheets of shortcrust pastry using one of three methods:
1) 'Hand-made' pies are formed by creating a cylinder of pastry that is joined to a circular base and filled with a filling of meat, fish, vegetables etc. Then a circular pastry lid is either crimped on or sealed with egg wash;

2) Sheets of pastry dough are pressed into reusable pie moulds or single-use aluminium foil dishes to form the shape of the pie or tart. The filling is then added, and for pies, a sheet of dough is laid over the top to form the lids and crimped around the edges and/or sealed with egg-wash (tarts do not have lids). In each method, the lids may be decorated with indentations, latticework pastry strips, or small shapes (e.g. leaves, hearts etc.) cut from sheet pastry using biscuit cutters (Figure 3a);

3) Pies are formed using a manual blocking/lidding machine (Figure 4). First a weighed piece of pastry dough is placed into a pie or tart mould and the blocking head is lowered to press the pastry to a uniform thickness. The casing is then filled and covered with a circular piece of pastry, and the blocking head on the machine is replaced by a lidding head. This is lowered and simultaneously forms and decorates the lid and trims off excess pastry. A video clip of this machine is available at www.johnhuntbolton.co.uk/Gallery/Video/easy_pieF.htm. The advantages of the blocking/lidding machine are first time-saving because the casing pastry does not have to be rolled to a sheet and the lid is simultaneously sealed and decorated; and secondly it produces uniform thicknesses of both the casing and lid. With a larger investment, two machines can be used to speed up production, one fitted permanently with a blocking head and the other with a lidding head, or the manual equipment can be replaced by semi-automatic electric machines together with a depositor used to measure out uniform amounts of filling.

Figure 4: Manual pie forming and lidding machines (John Hunt Ltd. at www.johnhuntbolton.co.uk)

Small pastie makers have a two-piece hinged mould that forms the shape of the final pastie (e.g. 'Cornish' pastie or slice pastie filled with meat, vegetables or cheese). A sheet of dough is placed over both halves of the mould, the filling is added to the lower half and the lid is lowered to crimp, seal and decorate the edges. Video clips of manual and semi-mechanised moulding equipment are available at www.johnhuntbolton.co.uk/English/Pages/gallery.html.

To form bread dough into the required shape, a small manual dough divider (Figure 5a) is used to produce uniform sized pieces. At larger scales of operation, cut pieces of dough can be shaped using either a conical moulder (Figure 5b), where they are formed into ball shapes, or in a cylindrical moulder that shapes dough into cylinders. The cylindrical moulder has 2-4 pairs of 'sheeting rollers' that have successively smaller gaps, to roll the dough gently into a sheet. This is then rolled into a cylinder; the ends are sealed and it is deposited into a baking tin.


a)


b)

Figure 5: Forming bread dough into shapes, a) Dough divider (Pie Master at www.piemaster.com) b) Conical dough moulder

There are many variations of these machines as well as other equipment that laminates sheets of dough with fat to produce Danish pastries and croissants, folding doughs to form pastries and rolls, and filling doughs to form sausage rolls and fruit bars such as 'fig rolls'.

Making cake batters

Cake batters are complex oil in water emulsions: added fats or oils are finely dispersed in water that contains both sugar, egg, starch and flavours, and also a foam that is produced by incorporating air when the batter is mixed or by adding baking powder. The cake texture depends partly on the amount of air incorporated during batter mixing and partly on the time and temperature of baking. Where emulsifiers are used, they improve the texture, volume and uniformity of cakes by controlling the size of air bubbles in the cake batter.

The ingredients in a cake mix each have particular functions: flour and egg provide strength and structure to the cake; sugar, fat and baking powder make a lighter texture; and milk and water make a heavier texture. It is therefore necessary to balance these ingredients. There are hundreds of different recipes for cakes, and 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 total weight of liquids.

The two methods of making cake batters are the 'sugar-batter' method and the 'flour-batter' method. In the sugar-batter method, fat, margarine or butter is beaten with sugar to create a cream. Any colouring or essences are added at this stage and then egg is mixed into the cream. The sieved flour and baking powder are then folded into the batter to achieve a smooth, lump-free batter but without 'toughening' it by too much mixing. Other ingredients (fruit, nuts etc.) are mixed into the batter and it is poured into a greased baking tin and baked. In the flour-batter method, sugar and egg are whisked together to form a batter. The flour is sieved to incorporate air, and folded into the egg/sugar mixture, causing as little disturbance as possible to its structure, until the batter is smooth and free from lumps. Any other ingredients are then blended into the batter. If the recipe uses margarine or butter this should be creamed (mixed) with an equal amount of flour before mixing with the egg/sugar. The sugar/egg mixture is added to the fat/flour mixture in about four equal portions, beating each portion together. The batter is then placed into a greased baking tin and baked.

Hotplates and ovens

Hotplates are used to bake a wide range of flatbreads, batter-based pancakes, crêpes and scones. They are normally made from aluminium or steel and may be coated with Teflon to give non-stick properties. They are heated either by gas burners or by thermostatically controlled electric elements embedded in the plate. In Ethiopia, a 'mitad' made from clay and fuel fired, or an electrically heated metal version are used to prepare the flatbread, injera. A non-stick hotplate can be made from a sheet of thick steel (e.g. 1 cm) that is heated over a fire. The steel plate is made non-stick by covering it with a 1 cm thick layer of salt and heating it to a dull red heat for 20-30 minutes. At this temperature, the salt melts and fills the microscopic cracks and indentations in the surface of the steel. After cooling, the excess salt is brushed away and the hotplate is coated with a thin smear of cooking oil. It should not be washed in water but scraped or wiped clean and re-oiled after use.

A well-designed bakery oven should have the following characteristics:

- It should be constructed from materials that can withstand intense heat without cracking or breaking.
- It should be well insulated so that it is economical in fuel use and loses little heat.
- The difference in temperature between the top and bottom of the oven should be constant without hot or cold spots.
- It should be possible to produce extra 'top' or 'flash' heat when required, and to inject either steam or water if products with a glazed crust are required.
- It should have easy access for products to be loaded/unloaded without causing burns to operators, and for maintenance and repairs.

There are two types of ovens: direct heating ovens that are heated by burning gas or solid fuels in the baking chamber; and indirect heating ovens that have a separate heater or firebox. Directly heated solid fuel ovens are used by many artisan and small-scale bakers as well as pizza ovens in restaurants, hotels and other food service outlets. They are low-cost, but risk contamination of products by smoke and ash. For example, the 'beehive' oven is a simple brick or stone structure, with one opening for the door that may also serve as the flue, or it may have a separate flue (Figure 6). Some designs have hollow brick walls that are filled with a mixture of broken glass, sand and/or salt for insulation. Fuel is burned on the stone hearth for 6-12 hours, often overnight, and the embers are raked out before baking begins. There should be sufficient heat retained in the top of the oven (or 'crown') and the oven walls to enable baking throughout the day

Figure 6: Beehive oven (Courtesy of Forno Bravo at www.fornobravo.com)

A common design of direct fuel-fired oven has a firebox built into one wall and a flue that is fitted with a damper to control the intensity of the draught through the fire. In operation, a low fire is burned overnight to heat the whole structure to a high temperature, and in the morning the fire is re-kindled to a high heat. The crown becomes intensely hot and this heat is then released during the day's baking. Bakers who use these ovens may bake a succession of products that require progressively lower baking temperatures as the oven cools during the day (e.g. in Table 2: starting with bread at 230°C, followed by buns at 210°C and ending with fruit cake at 177 °C).

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
French and Vienna breads	230	20-25

Bread rolls	230	10-12
Small cakes	221-232	10-12
Madeira, fairy cakes	221	10-12
Shortbread (small)	221	10-12
Puff pastry (sugar glazed or filled) Sausage rolls Sponge cakes (small)	215-227	12-15
Buns (medium rich)	210-220	12-15
Meat pies, patties (small)	215	15-20
Shortcrust pastry (e.g. pastries, tarts, custard pies)	204-215	15-18
Sandwich sponge cakes	204	20
Rich biscuits	204	18-20
Light gateaux	204	12-15
Shortbread (large) Rich sweet pastry	193-204 193-204	15-18 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	160	2-3 hours
Gingerbread	160	15-20
Meringues	121	10-15

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

Table 2. Baking temperatures and times for different products (From Fellows and Axtell, 2004)

Foods such as breads that require a surface crust and a moist interior need a high oven temperature, whereas products such as biscuits that have a low moisture content throughout are baked at a lower temperature to enable moisture to evaporate from the food without forming a surface crust.

The design and construction of directly heated fuel-fired ovens should enable the oven to bake quickly, but also retain sufficient heat to give several hours of baking. The crown contains stationary, very hot air that acts as a reservoir of heat, which is radiated down to bake the products. 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. There is therefore a compromise in oven design between having a large amount of heat retained by a high crown and a smaller amount of radiated heat that reaches the products. The oven design should also have a high capacity, low fuel requirement and relatively low costs for construction or repairs. The main disadvantage of direct fuel-fired ovens is the risk of contaminating products with smoke and ash.

Indirect ovens have continuous operation because the fire can be maintained without interrupting production. The simplest designs have a separate firebox with brick or tile-lined flues surrounding the baking chamber. The flues must have an access hatch to remove soot and the flue lining material must be able to withstand the intense heat without cracking, which would cause it to collapse. Alternatively, radiator tubes may be used to duct the hot air through the baking chamber, or fuel is burned between double walls. A ‘double-drum’ oven may be constructed using a 200-litre oil drum that has one end removed and a flue fitted to the other end. The horizontal drum is covered with soil to insulate it, with the flue rising vertically through the soil. A second smaller drum is the baking chamber, located on bricks inside the larger drum. A fire is lit between the two drums and food is placed in the baking chamber. The end of the drum is replaced while baking takes place, removing it as needed to rekindle the fire or empty the oven. If indirectly heated ovens are used, bakers may find it more useful to use several smaller ovens set at different temperatures to bake different products.

The rate at which a food bakes depends on a number of factors: 1) the type of food and size of the pieces. Smaller pieces heat faster because of the shorter distance that heat has to travel to the centre of the food; 2) the temperature of the oven; and 3) the speed that air moves in the baking chamber. Heating is by a combination of infrared energy that is radiated from heaters and oven walls; by conduction from the hearth through the baking pan or tray; and from circulating hot air. The hotter the oven, the more energy is radiated from the walls and conducted from the hearth, and so produces faster baking or roasting. The faster the air moves in the oven the quicker the food is heated. This is because foods are surrounded by a film of stationary air, which forms a barrier to heat moving into the food. The thickness of this 'boundary layer' depends on the speed of the air in the chamber. Fans that reduce its thickness increase the rate of heating and commercially produced ovens may be 'fan-assisted' to increase the rate of baking. Fans also distribute air uniformly through the baking chamber so that there are no hot- or cold-spots, and the same rate of baking is achieved in all parts of the oven.

A common design of small-scale gas or electric oven is the 'deck' oven, which has an insulated steel chamber fitted with a fan and a full-width door. The temperature is controlled automatically by either adjusting the flow of gas to burners at the base of the chamber or using a thermostat in electric ovens. Electric ovens should be fully earthed to prevent the risk of electrocution, and wiring should be located and insulated so that it is not affected by heat from the oven. Electric ovens may have microprocessor controls that are programmed to allow operators to select a code for each product without the need to remember the baking conditions. Microprocessors then automatically control the temperature and humidity in the baking chamber and the baking time. Multi-deck ovens (Figure 7) have 4-16 chambers stacked vertically. Each baking chamber has separate controls so that they can be simultaneously used for different products. The 'modular' construction allows production to be expanded by adding another deck without having to replace the entire oven. These ovens are usually fan-assisted and are fitted with steam mist injectors to produce a glazed crust on products. They are available in different sizes, with low or high crowns, and are widely used by small- and medium-sized bakeries, food service outlets, and in-store bakeries at larger supermarkets in some countries.

Figure 7: Multi-deck oven, (courtesy of Picard Ovens Inc. at www.picard.com)

Rack ovens have a single large baking chamber with a full-height door. A mobile rack of trays containing the products is wheeled into the oven and remains stationery during baking. At higher levels of investment, the 'rotary hearth' oven is similar to the rack oven but the rack of trays rotates inside the baking chamber. The 'reel' oven has a steel chamber and hinged trays fitted between slowly rotating wheels inside. As the wheels turn, the trays of food move vertically through the oven and also horizontally from front to back. They are loaded and unloaded as they pass the door. The movement through these ovens ensures that the products are baked uniformly. They have a high capacity and are suitable for larger-scale bakeries.

Fuels

The local cost and availability of fuels and electricity are one of the main considerations when selecting an oven, and they are also the largest operating cost for bakery businesses. Mains gas or bottled gas (propane or butane Liquid Petroleum Gas (LPG)) are the preferred options in countries that have an established gas distribution system and if the price is sufficiently low. This is because they burn cleanly and produce few odours that could contaminate products. In places that do not have gas, or it is too expensive, the next preferred option is electricity, especially if it is produced by hydro-electric power generation or other renewable sources. Solid fuels may be the lowest-cost option in countries that have significant coal reserves or extensive local forests for wood or charcoal production. Traditionally, wood has been cheap or free and hence widely used in bakery ovens, but deforestation in many countries has resulted in legal restrictions on its use and/or increased costs. Charcoal and coal are often more expensive than wood, but they produces an intense heat with little smoke. All solid fuels require considerable skill and experience to control the fire, and hence the temperature in an oven: a careless or unskilled oven operator can waste large amounts of fuel and also produce products that have inconsistent quality. Liquid fuels such as kerosene or diesel are not widely used to fuel ovens because they risk contaminating products with off-odours (other liquid fuels, such as petrol, should never be used because of the risks of fire and explosions).

Worked example: Calculating the size of bakery equipment

A small bakery expects to sell 250 loaves per day, with each loaf weighing 500g. Dough is mixed for 15 minutes, making it possible to mix 3 batches per hour, and a total mixing time of two hours is allocated per day. Wastage during dough preparation is estimated at 12% and the weight loss from dough during baking is 10%. Each batch of bread is baked for 20 minutes (i.e. 2 batches per hour) and a total of five hours per day is set aside for baking. Calculate the minimum size of the mixer and the oven that would be required.

The amount of dough required per day	= 250 x 0.5 kg = 125 kg
Plus extra to take account of losses	= 125 + (125 x 12%) + (125 x 10%)
	= 125 + 15 + 12.5 = 152.5 kg
Therefore the amount mixed per hour	= 152.5/3 = 50 kg per hour
And the size of the mixer is	= 50/2 = 25 kg (i.e. a bowl size of 30 kg to avoid over-filling).
The capacity required for the oven	= 250/5 = 50 loaves per hour
And the oven should be able to bake	= 50/2 = 25 loaves per batch.

Packaging

The types of packaging used for bakery products depend mostly on their required shelf life: those with a shelf life of a few days, such as cakes, flatbreads or bread, need minimal packaging, such as simple paper wraps or polythene bags for hygienic handing and to protect them from dust or other contaminants during retail or food service sales. Fragile products such as cakes or macaroons may be sold in cardboard cartons. Bakery products are usually distributed in trays or cardboard boxes. Plastic trays that are easier to clean have now largely replaced wooden trays. Products with a long shelf life, such as biscuits and crackers, require protection against breakage; picking up moisture that would lead to softening; and exposure to heat, light and air that would lead to development of rancid off-flavours. At a small-scale, biscuits may be packed into biscuit tins, jars, or cartons that have plastic inserts to hold the biscuits in place during distribution. The biscuits are filled by hand and the cartons are covered with moistureproof, airtight plastic film and heat-sealed. They are then contained in corrugated cardboard boxes or other containers to protect them against breakage. Long shelf life bakery products may also be packed in ‘modified atmospheres’, which are packs that contain a high concentration of CO_2. For example, this prevents mould growth on cakes and increases the shelf life to 3-6 months; and other bakery products have their shelf life increased from a few days to 3-4 weeks. However, the cost modified atmosphere packing equipment and an available supply of CO_2 gas may be too expensive for many small-scale bakeries.

Product safety and quality assurance

Baked products rarely cause food poisoning because the heat of the baking process kills most micro-organisms or reduces their numbers to safe levels. However, bakery products that contain meat, vegetable or cream fillings have the potential to contain food poisoning bacteria if they are not handled correctly and stored under refrigeration. Contamination may also arise after baking, caused by dirty slicing machines or poor staff hygiene. Freshly baked foods should therefore be handled under strict hygienic conditions and cooled and packaged as soon as possible. It is essential that they are adequately cooled before packaging. If warm products are packaged, moisture can condense on the inside of the pack, which would wet the food and lead to mould growth. The dry crust of bread and some other bakery products acts as a barrier to contamination by micro-organisms during storage, but migration of moisture from the interior of the product, or from high-moisture fillings in cakes and pastries, can allow spoilage by moulds. These products should be chilled or frozen to reduce this. Pies and samosas should be either kept in a refrigerator or stored in a hot display cabinet (above 63°C). Obtaining high quality ingredients, handling food safely, good temperature control and thorough cleaning are essential if these products are to be produced safely. Some baked products, such as cakes, may also contain preservatives including calcium propionate that is effective against moulds, or potassium sorbate that is effective against yeasts, moulds and some bacteria. However, these are not widely used at small scales of production.

Ingredient inspection

Most small bakers either buy flour directly from a local miller and other ingredients, such as special fats, sugar, salt, essences and yeast are purchased from wholesalers, retailers or from import agents. Management of bakery storerooms should comply with the following:

- Store sacks of flour on pallets away from walls to prevent dampness and allow easy cleaning around and underneath the sacks.
- Use stock rotation - first-in-first-out (FIFO)
- Ensure that the storeroom is dark and cool without temperature fluctuations
- Ensure that all rooms are sealed against insects, birds and rodents and that doors are not left open when not in use.
- Clean the processing room each day and the storeroom each week.

Small-scale bakers often have little control over the quality of ingredients that are supplied and therefore need to conduct checks to ensure they are of a suitable quality. The following tests are suitable for because they are relatively simple to use; they are sufficiently accurate for quality control purposes; they do not require sophisticated or expensive equipment; they do not require a high level of skill and they are relatively inexpensive.

Before use, flour should be checked for visible signs of flour mites, mould and for a mouldy or rancid smell. To test for the presence of flour mites, place a sample of flour onto a flat surface and use a ruler to spread it out and flatten it. Examine the flour for evidence of pimpling (disturbance of the surface) after about two minutes, which 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: Mix a sample of flour with petrol in a glass jar and stir thoroughly. 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, leaves etc. as well as measuring the degree of fineness of the flour. However, the cost of specialist laboratory sieves is relatively high and the investment can only be justified if there are recurring problems with suppliers. Sieve flour through a stack of analytical metal sieves, with the largest mesh size (1.6 mm) at the top of the stack and the smallest (0.038 mm) above the base. 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. 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, 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 by washing out the starch from the dough and examining the gluten that remains. 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%).

Solid shortenings (fats) and oils 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 and oils should be stored in a cool place away from sunlight, preferably in a refrigerator, and used as quickly as possible, with strict stock rotation to prevent losses.

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).

Process control
Process control in a bakery involves accurate weighing of ingredients, control over baking temperatures and times and correct handling procedures for products. 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. Operators should be given training to conduct the tests properly, and should be supervised to ensure that accurate information is recorded. All bakeries should have a regular cleaning routine, with each operator knowing what to clean, how often and to what standard.

References
Fellows, P.J. and Axtell, B.L., 2004. *Opportunities in Milling and Baking Processing - setting up and running a small flour mill or bakery*, CTA, Wageningen, Netherlands

Further information
A selection of books on bakery and baking ingredients can be found at www.chipsbooks.com/chipssl.htm

- *Baking and Baking Science*, Prejean, W., 2007, available at www.bakingand bakingscience.com
- *Baking for Profit: starting a small bakery*, Bathie, G., 1999, Practical Action Publishing, Bourton on Dunsmore, Rugby, UK.
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