PRACTICAL ACTION
Technology challenging poverty

# DAIRY PROCESSING

An overview

technical brief

## Introduction

Milk is a valuable nutritious food that, if untreated, will spoil within a few days. However, there are a number of preservation techniques that can be used at a small scale to extend its shelf life by several days, weeks or months. Some of these processing methods also produce foods that have different flavours and textures, which can increase the value of the milk when these products are sold. This Technical Brief gives an overview of the types of dairy processing that are possible at a small scale of operation. Details of the individual processing methods are given in other Technical Briefs in this series: *Pasteurised milk; Butter and ghee; Soured milk and yoghurt; Cheese-making; Ice cream production and Dairy confectionery.*

Other methods of milk processing, such as making dried milk powder, sterilised milk (Ultra-High-Temperature or 'long-life' milk and bottled sterilised milk), canned (evaporated or condensed) milk, or milk by-products such as casein, are not possible at a small scale because of the very high costs of equipment and the specialist technical knowledge required.

### Spoilage, food poisoning and preservation

Milk is not only nutritious for people, but also for bacteria. Because milk is a low-acid food, bacteria are able to grow in it and contaminate any products that are made from it. If milk is not properly processed or if it is contaminated after processing, bacteria can change the flavour, texture or colour of dairy products, to spoil them and make them unacceptable for sale. Other dangerous bacteria can grow in milk and cause food poisoning. Illnesses such as tuberculosis, brucellosis and typhoid fever can also result from using poor quality milk or milk that is not properly processed. All types of dairy processing therefore need careful control over the processing conditions and good hygiene precautions to make sure that products are both safe to eat and have the required shelf life. Processors must pay strict attention to hygiene and sanitation rules throughout the process, from milking the animal to final sale of products. These are described below and also in Technical Brief: *Hygiene and safety rules in food processing*.

### Dairy building and facilities

It is important that a suitable room is set aside as a dairy and it is only used for processing. The size of the room depends on the amount of milk being processed, but typically a small-scale unit that processes 100-500 litres per day requires an area of approximately 50m$^2$. A possible layout for a small dairy is given in Figure 1.

The room should be hygienically designed and easily cleaned to prevent contamination of products by insects, birds, rodents or micro-organisms. A panelled ceiling should be fitted rather than exposed roof beams, which would allow dust to accumulate that might contaminate products. There should be no holes in the ceiling or roof, and no gaps where the roof joins the walls, which would allow birds and insects to enter.

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All internal walls should be plastered or rendered with concrete that has no cracks that could harbour dirt or insects. The lower parts of walls should either be tiled to at least 1.5 metres above the floor, or painted with waterproof white gloss paint. Higher parts of walls can be painted with good quality emulsion paint if tiling is too expensive. Windows should be screened with mosquito mesh. Thin metal chains, or strips of plastic can be hung from door lintels to deter flying insects, or alternatively, mesh door screens can be fitted. The floor should ideally be tiled with floor tiles. However, these are expensive and may be slippery when wet. Good quality concrete, smooth finished and without cracks can be used instead. Vinyl-based floor paints can be used to protect floors, but they are expensive. Red wax household floor polishes should not be used because they wear away easily and could contaminate products.

Proper drainage prevents pools of stagnant water forming, which would allow insects and micro-organisms to breed. The floor should have a 2-3% slope to drain water to a drainage channel, which is covered with a metal grating that can be removed to clean the drain. A wire mesh cover should be fitted over the drain exit to prevent rodents and crawling insects getting into the building through the drain. This should also be easily removed for cleaning.

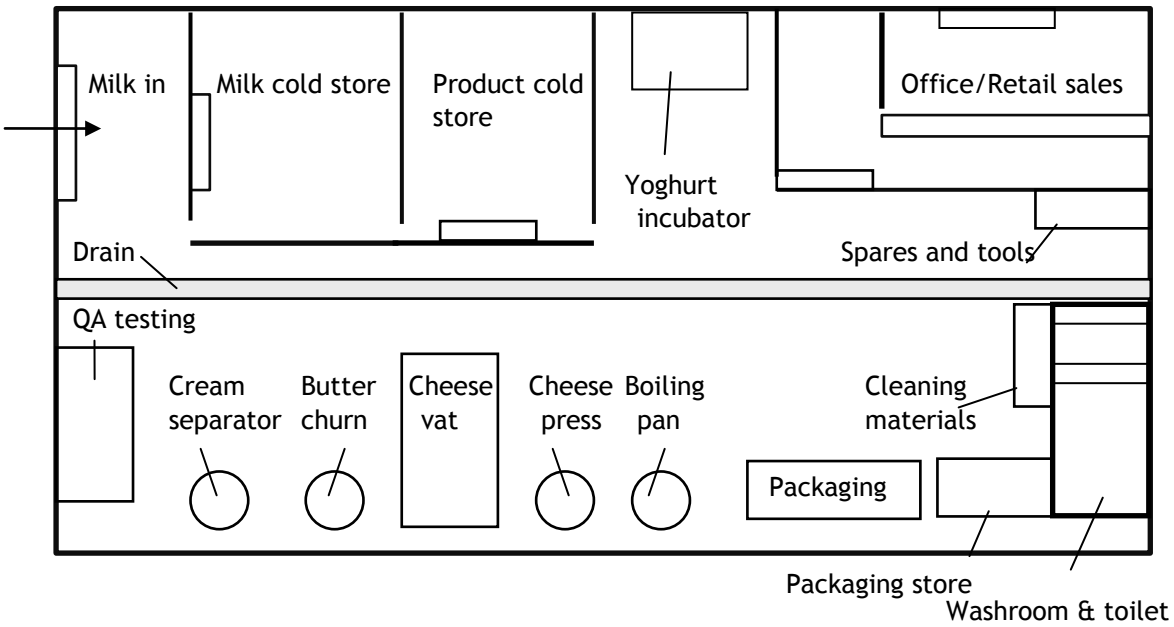


Figure 1: Layout of a small dairy
From: *Opportunities in dairy processing*

An adequate supply of clean water of drinking quality should be available from taps in the processing room (2-5 litres of water are required to process one litre of milk at a small scale of operation). Hosepipes with pistol grip adjustable sprays should ideally be used for washing down floors and equipment. If necessary, water should be treated to remove bacteria. The cheapest and easiest way is to use bleach (also known as 'chlorine solution' or 'hypochlorite'). Bleach is cheap and effective against a wide range of micro-organisms. Water for cleaning should contain about 200 ppm (mg/litre) of chlorine, made by mixing 1 litre of bleach into 250 litres of water. Commercial treatment units that use ultra-violet light to destroy micro-organisms in water are suitable for larger-scale processors that use a lot of water.

## Equipment

All dairy equipment should be designed and constructed so that it can be easily dismantled for cleaning (e.g. there should be no blank ends to pipework that would harbour stagnant milk). Mixing bowls, boiling pans etc. should have a smooth internal surface without corners, and all welds should be ground to a smooth finish. Ideally, all dairy equipment should be made from stainless steel, but alternatives include polished aluminium, or food grade plastic for containers and equipment that are not heated. Mild steel cannot be used because it will rust and

contaminate products, and brass, iron or copper cannot be used because they promote rancidity in milk fats. The layout of equipment within the room (Figure1) should allow food to move between different stages in a process without the paths crossing. This reduces the risk of contaminating finished products with raw milk. There should also be sufficient room behind equipment for cleaning.

## Cleaning and sanitation

Good sanitation is essential in all dairy processing. Equipment should be thoroughly cleaned after each day's production, using a cleaning schedule that indicates which equipment is to be cleaned, who is responsible for cleaning it, how it should be cleaned, how frequently it is done, and who is responsible for checking that cleaning has been done properly. All equipment should be washed with hot water and a cleaning agent that is recommended for use with dairy products, and then rinsed with chlorinated water. Equipment and surfaces should be allowed to dry in the air, because wiping with cloths can re-contaminate them. If they are available, brushes with coloured bristles are preferred because the coloured material can be seen easily if they are lost in machinery or in the product. At the end of a working day, a slight 'chlorine' odour in the processing room indicates that it has been properly cleaned. A summary of guidelines on hygiene and sanitation is given in Technical Brief: *Hygiene and safety rules in food processing*.

Dairy processing creates large volumes of liquid effluents that contain milk fat, lactose and protein, and this is highly polluting. Some wastes (e.g. whey from cheese-making) should be used as animal feed or to make drinks or whey cheese, rather than being discarded down the drain. Local regulations may require special treatment of dairy effluents and producers should consult local authorities to plan proper effluent disposal. If mains drainage is not available, at small scales of production a soak-away should be constructed in a place that cannot contaminate drinking water supplies or pollute local streams or lakes.

## Legislation

In most countries, the legislation for dairy foods is more stringent than for many other types of food. In addition to general regulations that govern labelling, weights and measures and hygiene when handling foods, special regulations govern the manufacture and sale of dairy products that are eaten cold without cooking. The legislation covers all aspects related to the operation of a dairy and the microbiological and chemical quality of products. Dairy processors should contact the responsible Ministry for copies of national regulations related to their products, and get advice from a university or Bureau of Standards if necessary to clarify what the regulations mean. They should also obtain a Health Permit from the Ministry of Health or Local Authority licensing the premises to be used for food production, obtain a Manufacturing Licence from the Local Authority or Ministry of Industry, and obtain Medical Certificates from the Health Authority to certify that all workers are fit to handle food.

### Quality assurance of milk supply

Because milk has a high risk of causing food poisoning, it is essential that processors pay great attention to the quality of milk that they buy. Two types of danger exist: infections from the living animal (e.g. Brucellosis) that are passed to the milk; and infections caused by contamination of the milk. Contamination of milk in the milking shed can come from contact with animal hides and faeces, poor quality water, dirty equipment and poor hygiene by milking staff. To ensure that good quality milk is used, dairy processors should only buy milk from reputable farmers or suppliers, and not rely on local street markets or middlemen. Milk should be bought using quality specifications and agreements with farmers. It is important that dairy farmers ensure that:

- Udders are washed using a clean cloth and clean water before milking. They should boil the cloth each day to sterilise it and dry it by hanging on a line in the sun.
- All milking equipment should be thoroughly cleaned and disinfected and after each use.
- People milking animals should wash their hands using clean water, because any bacteria on their hands can contaminate the milk.

- Animals should be inspected each day for disease (especially for mastitis) to prevent bacteria from an infected animal being passed by hands to healthy animals or into the milk.
- Personal hygiene rules are observed (see Technical Brief: *Hygiene and safety rules in food processing*).
- Milk is kept in containers that are covered and it is cooled as quickly as possible.
- Milk is transported to collection centres in shortest time possible.

Incoming milk in the dairy should be cooled to below 4°C (see below). It should be tested to ensure that it is fresh, safe, has been properly handled, and has not been adulterated with added water.

The level of quality assurance (QA) in processing depends on the risk associated with the particular product and is assessed by risk (or hazard) analysis using the HACCP (Hazard Analysis Critical Control Point) system (details in *How to HACCP*). Dairy manufacturers should carry out a hazard analysis for each of their products (see Technical Briefs for pasteurised milk, soured milks and yoghurt, butter and ghee, cheese making, ice cream and dairy confectionery).

### Appearance

Fresh milk should be slightly viscous, white with a yellowish tinge depending on the fat content (the fat content varies with the species of animal, the breed and the time of year). There should not be discoloration, lumps in the milk or a high viscosity. It should have a bland, slightly sweet taste and a pleasant smell. If a spoon is dipped into a sample of milk and slowly withdrawn, there should be no strings or threads of milk.

### Density

The density of milk can be measured using an instrument known as a 'lacto-densimeter' (or 'lactometer') (Figure 2). If a low reading is obtained, it indicates that the milk may have been diluted with water.

### Bacteria

A microbiological test that is appropriate for small-scale dairy processors is the 'methylene blue' test. Other tests are either too expensive, or require the specialist equipment and skills at a university Food Science department or Bureau of Standards.

The method is:

1. Mix a 20 ml sample of milk to ensure that the cream is evenly mixed in.
2. Place in a test tube and add 0.5 ml of dye solution (the dye is a 0.0075% solution of methylene blue1). The liquid dye should be stored in a foil-covered bottle in a cool, dark place away from sunlight, and can be kept for 2 months.
3. Seal the tube with a stopper and mix the contents by inverting the
4. Hold in a covered water bath at 36-38°C, so that the sample rema
5. Record how long it takes for the dye to fade (as an indication, if ins for 30 minutes[2] the milk has a satisfactory quality.

Figure 2: Lacto-densimeter with thermometer
Photo: Courtesy of Ningbo Goodwill Foreign Trade Co.Ltd,

1 Methylene blue dye is a powder that may be available from pharmacies or specialist ital city. The dye is made by dissolving the powder in distilled water.
2 Different times may be used in local dairy regulations and these should be consulted at the Bureau of Standards

Other tests
Measuring the fat content of milk requires chemicals and laboratory apparatus that are not likely to be affordable in a small dairy, and samples should be taken to a Bureau of Standards or university Food Science department for testing. A low fat measurement indicates that some of the cream has been skimmed from the milk or that it has been diluted with water.

## Methods of processing

There are four main methods used to process milk that are suitable for small-scale operation:

- Cooling fresh milk to extend the shelf life by a day or two, or freezing it (also making ice cream).
- Heating milk to destroy both contaminating micro-organisms and naturally occurring enzymes that change the flavour of milk.
- Making the milk acidic to slow down or prevent the growth of spoilage bacteria or food poisoning bacteria (this also changes the milk to a curd).
- Reducing the amount of water in milk products to slow down or prevent the growth of bacteria. This may be combined with adding sugar (to make milk confectionery) or salt (in cheese or butter production), both of which also prevent bacteria from growing.

### Cooling

Cooling does not destroy bacteria or enzymes but it slows down their activity. Cooled raw milk keeps its quality for a few days before it is processed. Milk products such as yoghurt, cheese, butter and pasteurised milk are also cooled to ensure they have the required shelf life for distribution to shops and retail storage. At the smallest (micro-) scale of operation, a refrigerator set at 4-5°C can be used to cool milk, but most dairy processors use a milk cooler (Figure 3) or cold store to cool milk in bulk before it is processed. Finished products should be stored in a separate dispatch store at 4°C +/- 2°C, or for frozen milk and ice cream, frozen in a freezer operating at below -18°C.


Figure 3: Milk cooler
Photo: Courtesy of Everest Instruments Pvt.

### Heating

There are regulations in most countries that specify the time and temperature that milk should be heated to pasteurise it. Most specify that milk should be heated to 63°C for 30 minutes (see Technical Brief: *Pasteurisation of milk*). Higher temperatures and shorter times are used in larger commercial operations but the equipment needed to do this is more expensive.

### Acidifying

Acid is produced in milk by the growth of certain types of harmless bacteria called 'lactic acid bacteria'. They are normally present in milk and are also used as starter cultures in the production of yoghurt (Technical Brief: *Soured milk and yoghurt*). Lactic acid bacteria convert milk sugar (lactose) into lactic acid, which increases the acidity of the milk and prevents the

growth of harmful bacteria. The removal of lactose means that these products can be eaten by people who suffer from lactose intolerance. The acid also creates the characteristic curd of yoghurt. The shelf life is extended by several days and the changes in flavour and texture make this a popular product in most regions.

### Removing water

Separating milk fat from the watery part of milk produces cream. This can be made as a product for sale, but care is needed because there is a greater risk of cream causing food poisoning. Production of cream is not recommended except by the most experienced small-scale dairies. However, cream is also used to make butter and ghee (see Technical Brief: *Butter and ghee*), which have lower moisture contents and are much safer. When butter is prepared and stored correctly, it can have a shelf life of several months. Clarified butter (ghee) also has a shelf life of several months. Both are high-value products and have a good market in most countries. In cheese-making (see Technical Brief: *Cheese-making*), a curd is produced and the watery part of milk is separated as 'whey'. 'Cottage' cheese or simple curd cheeses are relatively easy to make at a small scale, but hard cheeses require greater levels of investment, and more skill and expertise. It is recommended that market research is undertaken to find which types of cheese are popular before contemplating production, because in some areas the demand for hard cheese is small. Training in production should then be obtained from an experienced cheese-maker.

Another process is boiling milk to evaporate water and produce a brownish gel that is eaten as a snack food or sweet. The product has a shelf life of a few weeks and may have ingredients such as sugar, colour, spices, fruits or nuts added to give a variety of products.

## Summary

In summary, dairy products are low, medium or high-risk foods as follows:

| | |
|---|---|
| Low-risk dairy products: | Butter, ghee. |
| Medium-risk dairy products: | Soured (cultured) milks, yoghurt, cheeses, milk confectionery. |
| High-risk dairy products: | Cream, ice cream, pasteurised milk. |

Yoghurt, soured milks, butter, ghee, soft cheeses and milk confectionery are each highly suitable for small-scale operation, whereas production of hard cheeses, cream, ice cream and pasteurised milk require greater expertise and care.

## Equipment suppliers

Note: This is a selective list of suppliers and does not imply endorsement by Practical Action.

The website Smalldairy.com also lists equipment suppliers, laboratory supplies, books and contacts for small-scale dairy processing.

### Dairy processing equipment

- Fullwood Ltd., Grange Road, Ellesmere, Shropshire, SY12 9DF, UK. Tel: +44(0)1691 622391. Fax: +44 (0) 1691 622355. Website: www.fullwood.com
  Batch Pasteuriser. Specially developed for smaller quantities of milk, cream, yoghurt, cheese and cultured cream. Capacity: 150-500 litres/hour Power: Electric
- Dairy Udyog, C-230, Ghatkopar Industrial Estate, L.B.S. Marg, Ghatkopar (West), Mumbai - 400 086, India. Tel: +91 (0)22 2517 1636 / 2517 1960.
- Fax: +91 (0) 22 2517 0878. Email: jipun@vsnl.com
  Milk testing equipment & utensils. The equipment includes hand operated and electric centrifuges, funnels, beakers, flasks and milk collecting trays, cans and pails. Sealing and Filling Machines. Semi-automatic machine for packing liquids such as milk, oil, ghee etc.
- Glengarry Cheesemaking and Dairy Supply Ltd., 5926 Hwy#34, RR#1, Lancaster, Ontario, Canada, Tel: 1-888-816-0903 or 613 347 1141, Fax: 1 613 347 1167, E-Mail: info@glengarrycheesemaking.on.ca, Website: www.glengarrycheesemaking.on.ca

- APV Unit Systems, Pasteursvej, DK-8600 Silkeborg, Denmark. Tel: +45 8922 8922. Fax: +45 8922 8901. Website: http://www.apv.com/, select 'Industries' > 'Dairy' > 'Dairy unit systems'
  Pasteurising unit designed for small-scale heat treatment of liquid products (pasteurisation of milk and cream, but is also applicable for other products). The unit is provided with an electrical water heater and can be used where steam or hot water is not available. Capacity: 200-1,000 litres/hour Power: Manual

### Lacto-densimeters

- Ningbo Goodwill Foreign Trade Co., Ltd., William Chen. Add, Rm 1405, No 886 Baizhang East Road, Ningbo, China. Tel: 0574 87890522, E-mail on website: www.makewell.cn
- Kadam Dairy Equipments Pvt. Ltd., Pune - 411 004, Maharashtra, India, E-mail: kadamde@vsnl.net
- Everest Instruments Pvt., Nr. Chandan Park, Station Road, Visnagar-384 315, Gujarat, India, Tel: +91 276 5325855, Fax: +91-2765-221212, E-mail on website: www.everestinstruments.in/bulk_milk_cooler.html

### Ultra-violet water sterilisers

- Freshwater Systems, 10360 Sorrento Valley Rd., San Diego, Ca 92121, Website: www.freshwatersystems.com/c-157-uv-systems.aspx
- SunRay Technologies Inc. 80 Weathervane Dr., Killington, VT 05751, Tel: +1 802 4228680, Fax: +1 802 4228682, Website: www.sunraytech.com/

## References and further reading

## References


- *Dairy Processing* Practical Action Technical Brief
- *Basic Rules of Hygiene, Sanitation and Safety in Food Processing* Practical Action Technical Brief
- *Pasteurised Milk* Practical Action Technical Brief
- *Soured Milk and Yoghurt* Practical Action Technical Brief
- *The technology of traditional milk products in developing countries*, Technical Bulletin #85, Food and Agriculture Organization of the United Nations, Rome, 1990
- *Butter and Ghee*, Practical Action Technical Brief.
- *Cheese making*, Practical Action Technical Brief.
- *How to HACCP*. Dillon, M and Griffith, C., M.D.Associates, Cleethorpes Enterprise Centre, Unit 43, Jackson Place, Humberston, Grimsby, South Humberside DN 36 4AS UK. 1999.
- *Opportunities in Dairy Processing*, Fellows, P.J. and Axtell, B.L.A., (Eds.), CTA, 2008.


## Further reading


- *Appropriate Food Packaging: Materials and methods for small businesses* Fellows, P., Axtell, B., Practical Action Publishing, 1993.
- *Traditional Foods: Processing for profit* Fellows, P.J., (Ed.), Practical Action Publishing, 1997.
- *Dairy Processing* UNIFEM Practical Action Publishing, 1996.
- *Dairy Processing Handbook*, Alfa Laval/Tetra Pak Processing Systems, S-221 86, Lund, Sweden, 1995.
- *Dairy Science and Technology Education*, Goff, D., University of Guelph, Canada,
- *Dairy Science and Technology: Principles and Applications*, La Fondation de Technologie Laitiere et Department de Science et Technologie des Aliments Universite Laval. Les Presses de l'Universite Laval, Quebec. 1985.
- *Dairy Technology*. Walstra, P., Geurts, T.J., Noomen, A., Jellema, A. and van Boekel, M.A., Marcel Dekker. New York., 1998.


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- FAO Information also at www.fao.org/docrep/007/y3548e/y3548e09.htm or www.fao.org and search 'dairy processing book' for a list of publications that can be downloaded.
- *How to Clean*. Dillon, M and Griffith, C., M.D. Associates, Cleethorpes Enterprise Centre, Unit 43, Jackson Place, Humberston, Grimsby, South Humberside DN 36 4AS UK. 1999.
- *Preparation of Dairy Products, Agrodok 36*, Agromisa Foundation, P.O. Box 41, 6700 AA Wageningen, The Netherlands 1991.
- *Rural Dairy Technology,* O'Connor, C.B., ILRI Training Manual 1. International Livestock Research Institute (ILRI), Nairobi, Kenya. 1995.
- *Small Scale Food Processing – a directory of equipment and methods,* 2nd Edition, Azam-Ali, S., Judge, E., Fellows, P., and Battcock, M., Practical Action Publishing, UK. 2003.
- *Strategies for market orientation of small scale milk producers and their organizations*, Proceedings of a FAO Workshop, L.R. Kurwijila, J. Henriksen, A.O.O. Aboud and G.C. Kifaro (Eds.), Sokoine University of Agriculture, FAO Rome. 1995.
- *The Food Hygiene Handbook*, Sprenger, R.A., Highfield Publications. Doncaster DN5 7LY, UK, 2002.
- *Tools for Agriculture: A Guide to Appropriate Equipment for Smallholder Farmers,* Practical Action Publishing, CTA & GRET, 1992
- *Village Milk Processing*, Animal Production and Health, Lambert, J.C., Paper no. 69, FAO, Rome. 1988.


## Support organisations

- Agromisa Foundation, P.O. Box 41, 6700 AA Wageningen, The Netherlands.
- Centre for Dairy Research, Madison, WI. Dairy & Meat Officer (Institutional Support & Training), Animal Production & Health Division, Food and Agricultural Organization (FAO), Rome, Italy
- ILRI-Kenya, P.O. Box 30709, Nairobi, Kenya, Tel: 254-2 630743. Fax: 254-2 631499.E-mail: ILRI-Kenya@cgiar.org. Website: http://www.cgiar.org/
- International Livestock Research Institute (ILRI) Ethiopia, P.O. Box 5689, Addis Ababa, Ethiopia. Tel: (251-1) 613215. Fax: (251-1) 611-892. E-mail: ILRI-Ethiopia@cgiar.org. Website: http://www.ilri.org/
- SKAT, Vadianstrasse 42, CH-9000 St. Gallen, Switzerland. Tel: +41 71 228 54 54. Fax: +41 71 228 54 55, E-mail: info@skat.ch, Website: www.skat.ch.
- Strengthening African Food Processing, www.safpp.net

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