VOLUME 1

Hygienic milk handling, processing and marketing

Reference guide for training and certification of small-scale milk traders in East Africa

KENYA DAIRY BOARD
"Quality Milk for Health"

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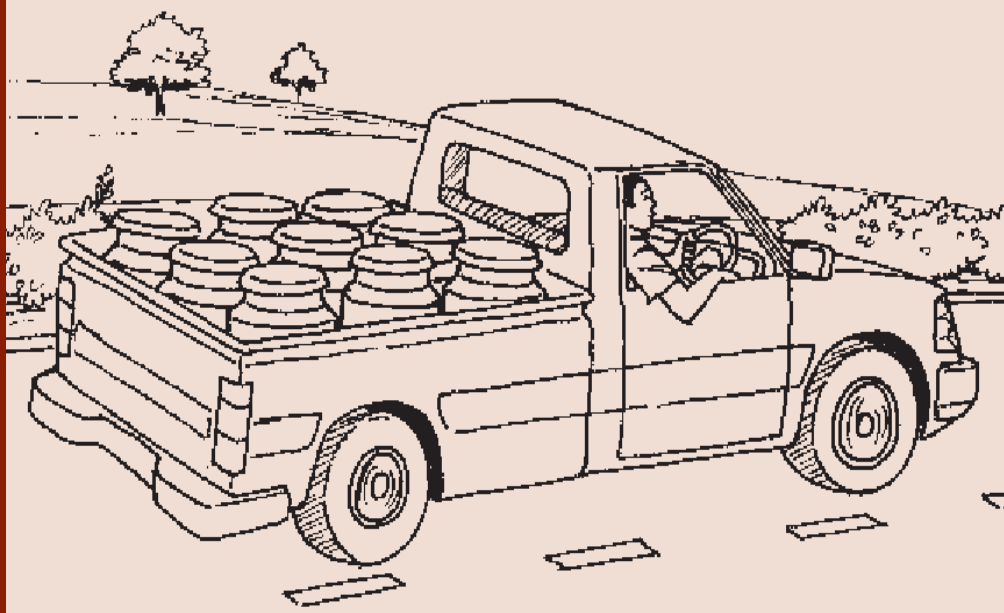
PROJET D'APPUI AU DEVELOPPEMENT DE L'ELEVAGE BOVIN LAITIER

TDB
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ECAPAPA
A Programme of the Association for Strengthening Agricultural Research in Eastern and Central Africa (ASARECA)

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ILRI
INTERNATIONAL LIVESTOCK RESEARCH INSTITUTE



Lusato R. Kurwijila

Volume 1

Hygienic milk handling, processing and marketing: Reference guide for training and certification of small-scale milk traders in Eastern Africa



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February 2006

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Layout and illustrations	Lilian Ohayo
Printing	Regal Press Kenya Limited, Nairobi

Correct citation: Kurwijila, L.R. 2006. *Hygienic milk handling, processing and marketing: reference guide for training and certification of small-scale milk traders in Eastern Africa.* ILRI (International Livestock Research Institute), Nairobi, Kenya.

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Acknowledgement

This training manual is a result of lessons learnt during two collaborative projects. The first, funded by the UK Department for International Development (DFID), studied informal dairy markets in Kenya, Tanzania and Ghana and involved the International Livestock Research Institute (ILRI), the Kenya Agricultural Research Institute (KARI) and Sokoine University of Agriculture. The other project was between ILRI and the Eastern and Central Africa Programme for Agricultural Policy Analysis (ECAPAPA). Between 2002 and 2005, ECAPAPA embarked on a two-phase programme titled *"Rationalisation and harmonisation of policies and standards in the dairy industry in Eastern Africa"*. The first phase dealt with harmonisation and rationalisation of standards of milk and dairy products in Eastern Africa. The second phase addressed the issue of training of informal milk traders for certification so that they can begin to participate in dairy markets in a manner that is acceptable to dairy industry regulatory authorities, by observing quality and safety aspects of traded milk and dairy products. Under this programme ECAPAPA brought together dairy industry experts from Kenya, Rwanda, Tanzania and Uganda to develop a training programme that would enhance the competence of informal milk traders in hygienic milk handling, marketing and small-scale processing so as to ensure that consumers are supplied with nutritious and safe milk and dairy products at all times.

The contributions of the following national resource persons are highly acknowledged: Dr Philip Cherono (Kenya Dairy Board), Mr Isha Muzira (Dairy Development Authority, Uganda), Mr Obed Ndankuu (Tanzania Dairy Board) and Dr Michel Ngarambe (Ministry of Agriculture, Rwanda). Ato Tessema Abebe of ILRI's Dairy Technology Unit in Debre Zeit, Ethiopia helped to compile some of the photographs used in this manual. Dr Amos Omore and Ms Tezira Lore of ILRI performed their task of coordinating the work of the national resource persons with much diligence thus enabling this manual to be completed on time.

We hope that this manual, set in two volumes, will provide a useful tool for training and certification of informal milk traders by national dairy regulatory authorities in the wider Eastern and Central Africa region. It may be translated into local languages where appropriate.



Foreword

In most countries in sub-Saharan Africa, smallholder dairy farmers, milk producers, milk traders and processors account for more than 80 per cent of the production, marketing and value addition in the dairy industry. However, government policies have tended to discourage informal market players in favour of centralised, medium- and large-scale milk processors. Recent research in Ghana, Kenya and Tanzania by ILRI and national partners has shown that informal markets provide high prices to producers while delivering milk at prices that are affordable even to poor consumers. Contrary to perceived public health concerns, the marketing of raw milk does not pose public health risks as most consumers boil milk before drinking it.

Assessment of the quality of traded milk and milk products has shown that value addition through small-scale processing is important for income generation and reduction of post-harvest losses. Lack of training contributes to poor hygiene and low microbial quality of raw milk and processed dairy products. Stakeholders and regulatory authorities in Ghana, Kenya and Tanzania have indicated the need to improve milk handling and processing through training of various cadres of milk traders, producer groups, transporters, milk bar operators and small-scale processors in order to meet quality and regulatory requirements.

In Kenya, a training module for informal milk traders titled *"Improve the quality of your milk and please your customers"* has been developed and tested by ILRI, the Kenya Dairy Board and the UN Food and Agriculture Organisation (FAO). Similar modules are being developed for milk producer groups, transporters, milk bar operators and regulatory authorities. Diploma and graduate dairy / food technologists with adequate skills in participatory training and adult learning techniques can deliver such training modules. However, in many countries most public advisory service providers and private business development service (BDS) providers for small-scale dairy industry operatives are not specialised dairy / food technologists.

In the past, "Training of Trainers" courses in dairy technology have been conducted by the International Livestock Centre for Africa (ILCA) at Debre Zeit Station in Ethiopia, FAO Regional Dairy Training Team (FAO-RDTT) at the Dairy Training Institute in Naivasha, Kenya and more recently by the FAO Post-harvest Losses

Project at the ILRI Debre Zeit Station. Participants at these courses were mainly diploma holders and university graduates in the fields of general agriculture, animal science and veterinary medicine. The need to develop minimum competencies for training in dairy technology for agricultural extension officers and service providers in medium and small enterprises (MSEs) who do not have specialist dairy training cannot be overemphasized. A large pool of competent trainers and advisors in grassroots dairy technology education for farmers, traders and small-scale milk processors will be required in the years to come in order to transform and integrate the large informal sector into a regulated one while enhancing the important role of small-scale operators in contributing to household incomes and nutrition of the poor, and the economy as a whole.

This generic guide has been designed to assist dairy advisory service providers and trainers to design appropriate programmes to train and advise:

- Milk producer groups on hygienic milk handling on the farm
- Milk transporters on hygienic and profitable milk transportation business practices
- Small-scale traders on hygienic and profitable milk handling and marketing
- Milk bar / milk parlour / kiosk operators and retailers on hygienic milk handling and profitable milk bar operation and retailing.
- Small-scale processors on hygienic and profitable small-scale milk processing
- All small-scale dairy chain operators on basic and essential regulatory procedures, standards and regulations governing the technical and business operations in the dairy industry
- All small-scale dairy chain operators on milk marketing and business planning

In order to be able to deliver on the above core competencies, trainers need to know and understand aspects of:

- Milk quality management at the farm
- Milk quality management at milk collection / cooling centres

- Milk quality and management of milk transportation and small-scale milk trade
- Appropriate technologies for small-scale milk processing and preservation
- Appropriate record keeping and business management for small-scale milk traders, transporters and processors
- The code of hygienic practices and regulations governing milk handling, transportation and processing

The generic guide is prepared in two volumes. Volume 1 covers the subject content required to impart the necessary basic knowledge and understanding of dairy hygiene and milk quality control, and how best to deliver it taking into account the conditions under which small-scale farmer groups, milk traders and small-scale processors operate. A three- to four-week long "Training of Trainers" course may be designed to develop the above-listed competencies of trainers and advisors to enable them master the requisite subjects contained in this volume.

Volume 2 is designed for trainers of small-scale dairy farm workers, transporters, traders and processors. The guide will assist trainers to plan, organise and deliver effective short courses of up to three weeks' duration. This will be particularly useful to trainers and BDS providers who do not have diploma- or degree-level training in dairy technology and are not professional trainers. For purposes of this guide, the term "milk traders" refers to itinerant milk traders, milk transporters, milk bar/parlour/kiosk operators and retailers, while the term "processors" refers to small-scale milk processors.

Glossary of terms

Agglutination	Undesirable sedimentation at the bottom of the cheese vat during manufacture of cottage cheese.
Agglutinin	Antibody in milk that causes agglutination during manufacture of cheese.
Agitation	Stirring of whole milk, cream or curd during the manufacture of butter or cheese.
Albumin	A water-soluble protein component of whey that coagulates on heating.
Alkaline	Having a pH greater than 7.
Antibiotics	Drugs used to treat bacterial infections in animals. Milk from cows treated with antibiotics may contain residues of these drugs which may inhibit the lactic bacteria used in production of cheese and fermented dairy products.
Antibody	Protein released in the blood that is generated in reaction to a foreign protein (antigen) that has entered the body. Antibodies produce immunity against certain micro-organisms or their toxins.
Bacteriophage	A virus that attacks and destroys bacterial cells.
Brine	A solution of water and salt having a high concentration of sodium chloride.
Buffer	A substance which, in solution, is capable of neutralising both acids and bases while maintaining the original acidic and basic qualities of the solution.
Buffering capacity	The ability to maintain the pH of a solution around neutrality (pH 7).
Bulk starter	The starter culture of lactic acid bacteria that is used to initiate batch fermentation of cheese or other cultured dairy products.
Calcium chloride	A soluble form of calcium that is used in cheese manufacture to aid in coagulating milk when the mineral content is out of balance. It may be legally added in amounts up to 0.02 per cent of weight of the milk.
Calcium hardness	Build-up of calcium on the surface of equipment resulting from hard water.
Casein	The main protein in milk, comprising about 80 per cent of milk protein. It consists of three subcomponents: alpha-, beta- and kappa-casein.
Cheddaring	Matting of the curd during manufacture of cheese.
Chlorinated wash	A cleaning solution containing chlorine as an active ingredient, usually at a concentration of 100–200 parts per million.

Chymosin	The main enzyme in calf rennet that forms the curd in cheese. It is also available as a fermentation-derived product.
Coagulant	An enzyme that removes the kappa-casein fraction from the casein micelle resulting in the formation of a protein gel.
Coagulation	The binding together of the casein micelles to form a gel-like mass, either due to the action of enzyme (coagulant) or acid.
Coccus	A term used to describe the spherical shape of bacteria. Plural, cocci. It is also often used to refer to the *Streptococcus* genus in an Italian type cheese starter or in yoghurt.
Coliforms	A group of bacteria that comprises all aerobic and facultatively anaerobic, Gram-negative, non-sporeforming rods able to ferment lactose with the production of acid and gas at 35°C within 48 hours. The presence of coliforms in dairy products indicates unsanitary conditions or poor hygiene during processing.
Colony-forming unit	The number of bacteria as defined by the number of colonies on an agar plate. Often abbreviated CFU. One colony can represent one free cell or a large number of cells if the strain grows in clumps or chains.
Colostrum	The secretion of the mammary glands for the first few days of lactation. It has a strong odour, bitter taste, slight reddish-yellow colour, and a high level of immunoglobulins that confer disease resistance from cow to calf.
Cook	To elevate the temperature of curds and whey during cheese processing in order to increase separation of the whey.
Cultured buttermilk	Skimmed or partly skimmed milk that has been fermented by the action of lactic acid bacteria.
Curd	A casein coagulum formed by adding enzyme coagulant or acid to milk.
Death phase	The phase of microbial growth characterised by a decrease in population usually due to competition, reduction of available nutrients and build up of metabolic waste.
Dehydration	Loss of water.
Denature	To modify the molecular structure–usually of a protein–by heat, acid, alkali or ultra-violet radiation.
Drain	In cheese processing, to remove the liquid phase (whey) from the solid phase (curd).
DVS	Abbreviation for direct vat set culture, a highly concentrated culture that is used to directly start the fermentation of cheese or a cultured product.



Elasticity	Describes the degree of resilience of cheese to pressure and is reflected in its springiness and ability to form characteristic openings (eyes) of uniform size and shape.
Emulsifier	A surface-active compound which reduces the tension between air-liquid and liquid-liquid interfaces.
Enzyme	A protein compound which catalyses chemical reactions to form new compounds or physical forms. Examples are *chymosin* which catalyses the formation of the casein gel and *lipase* which catalyses the breakdown of milk fat and formation of flavour compounds.
Facultative anaerobe	A micro-organism that does not require oxygen for growth but will respire it if present in the growth medium.
Fermentation	Bulk growth of microorganisms on a growth medium.
Fortification	In yoghurt manufacture, the addition of ingredients (e.g. skimmed milk powder) to increase the milk solids-not-fat content and improve the viscosity of the end product.
Freezing point	The temperature at which a liquid turns to a solid. The freezing point of milk -0.54°C
HACCP	Abbreviation of *Hazard Analysis Critical Control Point.* It is a system that is applied in the food manufacturing industry to provide assurance of food quality and safety by analysing the hazards associated with a process and monitoring, reducing or eliminating those hazards at identified critical control points.
Hawker	A person who buys milk from producers and sells it to consumers on the street or from door to door.
Heal	In cheese manufacture, to rest the curd after cutting it to allow it to firm up.
Heterofermentative	Describes lactic acid bacteria that ferment glucose to produce equal molar amounts of lactic acid, CO_2 and ethanol.
Homofermentative	Describes lactic acid bacteria that ferment glucose to produce over 50 per cent of total acid as lactic acid.
Homogenisation	A mechanical process used on fresh milk to prevent the separation of a cream layer. It reduces the size of fat globules so that they are uniformly and evenly distributed throughout the milk.
Hydrolysis	A chemical reaction in which a molecule is broken down into two parts by the addition of a molecule of water.

Hypochlorite	A chemical solution that is used to destroy microorganisms on utensils after cleaning.
Ititu	Traditional concentrated fermented milk produced by Borana pastoralists in southern Ethiopia.
Lactic acid	A mild flavoured acid produced by bacteria in dairy products from lactose fermentation, resulting in the lowering of milk pH. Chemical formula: $C_3H_6O_3$, molecular weight: 90.08.
Lactic acid bacteria	A group of bacteria commonly added to milk as starter cultures to ferment lactose to lactic acid. Lactic acid is responsible for the fresh acidic flavour of unripened cheese and is important in forming and texturing of the curd.
Lactose	A disaccharide sugar consisting of glucose and galactose. Lactose makes up about 50 per cent of the solids in milk.
Lag phase	The first phase of bacterial growth that occurs before cell division takes place, during which time the bacteria adapt to the growth medium and activate enzymes to metabolise nutrients.
Lipase	An enzyme that aids in the breakdown or digestion of fats.
Lipolytic	Describing the action of lipase enzymes in breaking down lipids into free fatty acids.
Log phase	The phase of bacterial growth when cells multiply rapidly and the population increases.
Lysogenic	Describing substances that result in the lysing or breaking of bacterial cells.
Mastitis	An inflammation of the udder usually caused by infection.
Mesophilic	Describes a micro-organism that grows optimally at moderate temperatures, usually between 21 and 32°C.
Micelle	A microscopic, ball-shaped cluster of casein proteins suspended in the fluid component of milk.
Microaerophilic	Describes a micro-organism that requires oxygen for growth but can tolerate lower levels of oxygen and grow anaerobically to some extent.
Milk	The whole fresh, clean lacteal secretion obtained by the complete milking of one or more healthy cows excluding that obtained during the first seven days after calving.
Milk collection centre	A centre equipped with facilities for bulking of milk, with or without cooling facilities.

Milk collection point	An assembly point for receiving milk for onward transportation to a collection centre or cooling centre.
Milk cooling centre	A centre equipped with facilities for bulking and cooling of milk.
Milk stone	A hard deposit on the surface of milk processing equipment primarily composed of milk albumin, calcium, denatured casein and phosphorus.
Milling	The process of passing the curd through a mill, which cuts it into small pieces.
Mixer/moulder	A machine that heats and stretches cheese curd using hot water and a screw-like extruder. The hot curd is then moulded into a desirable form.
Multiple-strain blend	Describes a culture composed of more than one strain of bacteria to reduce the possibility that a phage will completely stop the culture, and/or to develop flavour and body characteristics that can not be provided by one strain alone.
Organoleptic	Describing the use of the senses.
Pasta filata	A class of cheese that is processed by heating and stretching the curd to form a smooth, uniform mass before cooling. Mozzarella cheese is an example.
Pasteurisation	Process of heating food for the purpose of destroying harmful microorganisms.
Pasteurised milk	Milk which has been subjected to pasteurisation and which, if retailed as such, has been cooled without delay and packaged with minimum delay under conditions which minimise contamination. The product must give a negative phosphatase test immediately after heat treatment.
Peptidase activity	The measure of the ability of peptidase to hydrolyse simple peptides.
Peptides	Amino acids that are grouped together to form short protein chains.
pH	A measure of hydrogen ion concentration. A pH of 1 is acidic while pH 14 is basic; the pH of normal fresh milk is 6.5 to 6.6.
pH control	The process used during production of bulk starter to maintain the optimum pH for the growth of the starter bacteria. This is typically accomplished by adding either ammonium hydroxide or potassium hydroxide to the medium.
pH meter	An instrument which measures pH.
Phage inhibitory media	Media used for bulk starter production that is designed to reduce phage growth and maximise culture growth

Phosphoric acid	A strong acid which can be added to the cottage cheese vat during the cooking stage to deter matting of the curd.
Plaque	A clear spot on an agar plate that represents the action of a phage as it lyses the bacteria.
ppm	Abbreviation for *parts per million.* Indicates the concentration of an active ingredient when mixed with a diluent, usually water.
Press	In cheese manufacture, to apply pressure to curd to give it shape, squeeze out whey and expel air.
Protease	An enzyme that breaks up protein molecules into smaller compounds called peptides.
Protein	A substance found in all living cells, which is also an essential element in human diets. Meat, eggs and milk are protein-rich foods. Casein is the major milk protein.
Proteinase	Synonym for protease.
Proteolysis	The hydrolysis of proteins by a protease enzyme, forming simpler and more soluble compounds.
Proteolytic enzyme	Any enzyme whose action results in the hydrolysis of proteins or peptides to simpler and soluble compounds.
Psychrotroph	An organism that grows optimally at cold temperatures (at or below 7°C) and has a growth temperature range of up to 30°C.
Rennet (chymosin)	An enzyme (natural or synthesised) that coagulates casein.
Ripening	In cheese manufacture, the stage when the cheese curd is left to rest under carefully controlled conditions to allow for flavour and texture development.
Rod	A cigar-like shape used to describe the cell shape of certain bacteria. It is often used to refer to the genus *Lactobacillus* used in manufacture of Italian-type cheese or yoghurt.
Salting	In cheese manufacture, the process of applying salt or brine to the curd to act as a preservative and add flavour. It also results in slower pH change and removal of moisture.
Sanitise	To reduce the number of microorganisms on the surface of equipment, typically done by washing with a suitable chemical solution.
Sediment	Residue or precipitate which forms at the bottom of a solution.

Set	A period of no movement of the milk in a vat to allow for coagulation of milk by enzymes.
SNF	Abbreviation of *solids-not-fat* and includes lactose, protein, and minerals.
Somatic cell	A cell that forms the body of an organism. A high number of somatic cells (e.g. leucocytes) in milk can indicate disease or infection.
Specific gravity	The ratio of the density of a solution to that of an equal volume of water at the same temperature.
Standard plate count	A microbiological counting method for determining the number of viable cells or colony-forming units in a food product.
Standardisation	The process of adjusting the butterfat and/or solids content of milk by adding or removing cream or non-fat milk solids so as to achieve a processed milk product of specified butterfat content.
Starter	A culture of lactic acid bacteria that is used to initiate fermentation.
Stationary phase	The phase of bacterial growth characterised by reduced growth rate as the bacteria begin to exhaust the available nutrients.
Strippings	The last drawn milk from the udder at each milking.
Syneresis	The contraction of curd pieces resulting in the expulsion of moisture from whey.
Thermophilic	Describes microorganisms that grow optimally at temperatures greater than 45°C.
Titratable acidity	The measure of titratable hydrogen ions in milk or whey. It may also be used to estimate the pH of the curd.
Vat	A container used for the first stages of the cheese making process.
Vendor	A person who buys milk from producers for sale to consumers.
Viscosity	The magnitude of resistance due to shear forces within a liquid.
Whey	The liquid removed from cheese milk, composed mostly of water, lactose, and proteins.
Whey protein	Water-soluble protein, which is not coagulated during manufacture of cheese. It is rich in essential amino acids.
Wheying-off	Free whey escaping from a curd as may occur during processing of yoghurt.

CHAPTER

1

Introduction

Why is milk hygiene important?

Anyone dealing with raw milk on a day-to-day basis knows very well how quickly it becomes sour when it is stored for long periods at high ambient temperatures prevalent in tropical and subtropical countries. This is because the inherent lactic acid bacteria and contaminating microorganisms from storage vessels or the environment break down the lactose in milk into lactic acid. When sufficient lactic acid has accumulated, the milk becomes sour and coagulates, much like when you add sufficient lemon juice or vinegar to fresh milk. Raw milk that contains too much lactic acid, even if it does not appear to be curdled, will coagulate when heated. This acidity is known as "developed acidity" and such milk is not acceptable for sale to consumers or milk processors.

The number of spoilage bacteria in raw milk depends on the level of hygiene during milking and the cleanliness of the vessels used for storing and transporting the milk. During the first 2–3 hours after milking, raw milk is protected from spoilage by inherent natural antibacterial substances that inhibit the growth of spoilage bacteria. However, if the milk is not cooled, these antibacterial substances break down causing bacteria to multiply rapidly. Cooling milk to less than 10°C may prevent spoilage for up to three days. High storage temperatures result in faster microbial growth and hence faster milk spoilage.

Raw milk is also known to be associated with pathogenic bacteria which cause milk-borne diseases such as tuberculosis, brucellosis or typhoid fever, among others. Hygienic milk production, proper handling and storage of milk, and appropriate heat treatment can reduce or eliminate pathogens in milk. In many countries, milk processing factories are required by law to pasteurise milk before selling it to



the public. Many consumers also routinely boil milk before drinking it to protect themselves from milk-borne diseases. Processed milk must be handled hygienically to avoid post-processing contamination.

So whether one is selling milk directly to consumers or to a processing factory, it must be handled hygienically so that it remains fresh and capable of being heated without curdling. Hygienic milk handling includes using clean equipment, maintaining a clean milking environment, observing good personal hygiene and preserving the quality of milk during storage and transportation to the consumer or processing plant.

In this guide, you will learn how to produce milk hygienically and handle it properly during storage and transportation so that it stays clean and fresh. You will also learn how to add value to raw milk by processing it into nutritious and safe dairy products. In order to ensure that small-scale milk handlers adhere to acceptable minimum standards of quality, a section has been included on the code of hygienic practices, dairy regulations and standards for guidance and use in the training and provision of advisory services to farmers.

Here is a summary of the chapters that follow:

Chapter 2	introduces clean milk production on the farm
Chapter 3	describes quality assurance in milk collection by farmer groups
Chapter 4	describes simple methods for pasteurising milk
Chapter 5	describes simple technologies for production of cream, butter and ghee
Chapter 6	describes techniques for hygienic production of fermented milk
Chapter 7	gives recipes for production of some traditional and exotic cheeses that can be easily adapted to small-scale processing
Chapter 8	introduces basic dairy records and business practices
Chapter 9	introduces basic elements of the code of hygienic practices, regulations and standards for the dairy industry
Appendix 1	gives a brief description of additional milk quality control tests

CHAPTER

2

Clean milk production on the farm

Good hygienic practice is very important in the production of clean milk. Clean milk has the following characteristics:

- Low bacterial count
- Pleasant creamy smell and colour
- No obnoxious odours
- No dirt and extraneous matter
- No residues of antibiotics, sanitisers or pesticides

2.1 Sources of milk contamination

Raw milk may be contaminated by bacteria from several sources. These include:

- Udder and udder flanks
- Milker
- Milking environment
- Milking equipment
- Vessels used for milk storage and transportation



2.2 Conditions for clean milk production

Here are some important points to observe in order to produce clean milk:

- Milking should be carried out in a well-ventilated barn with adequate lighting.
- The floor of the milk barn must be durable and easy to clean, preferably made of concrete.
- After use, milking vessels and equipment must be cleaned with potable water, sanitised and dried in the sun on a drying rack. Suitable disinfectants, such as hypochlorite solution, should be used at the recommended concentrations.
- Milkers must be healthy and not suffering from contagious diseases or ulcers.
- Only healthy cows should be milked. Cows suffering from mastitis should be milked last and their milk discarded. Milk from cows on antibiotic treatment should not be sold until the specified withdrawal period (usually 72 hours or more) has elapsed.
- Colostrum (the milk produced in the first five days after calving) should not be mixed with normal milk. Calves must be allowed to suckle their dams and excess colostrum may be given to other calves or fed to pets (cats and dogs).
- During milking, the first strips of milk (fore milk) should be milked into a separate, black-coated cup (strip cup) to check for mastitis. The fore milk should then be discarded.
- Where possible, raw milk should be cooled using simple methods such as immersing milk cans in a trough of running cool water (Figure 2.1) or evaporative cooling (Figure 2.2).

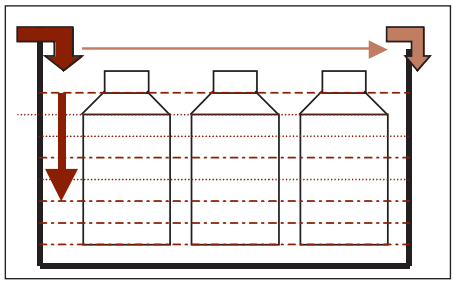


Figure 2.1: In-can immersion cooler



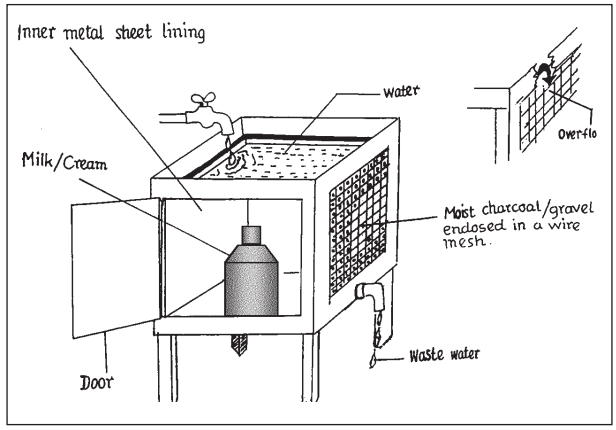


Figure 2.2: Evaporative charcoal cooler

2.3 Milk preservation on the farm

While most smallholder farmers do not have cooling facilities, it is important to cool milk and store it at as low a temperature as is practically possible if it cannot be delivered within 2–3 hours after milking. This is particularly important for evening milk or where morning milk cannot be transported to the milk collection point within 2–3 hours. Simple means of cooling, such as immersing milk cans in ice blocks or cold water in a trough, are better than leaving the milk uncooled. Where available, domestic refrigerators may be used but avoid freezing milk as this destabilises the fat. Figure 2.3 shows the effect of temperature on the rate of microbial multiplication; the lower the temperature the slower the rate of bacterial growth.

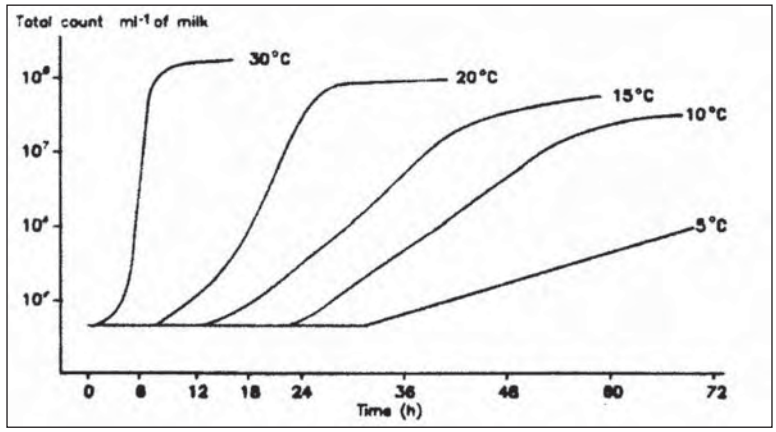


Figure 2.3: Effect of storage temperature on bacterial multiplication

2.4 Good milking procedure

It is important to follow proper milking procedures in order to obtain milk of good and consistent quality. A properly executed routine milking procedure is part and parcel of clean milk production.

The following steps should be followed:

Milk at the same time every day	Ensures consistent butterfat content. Usually, the longer the milking interval the higher the butterfat content and volume of milk. The reverse is true for shorter intervals. There are no economic benefits of milking more than twice a day unless one has very high yielding cows (>40 litres/day). For most smallholder producers, a twice-a-day milking routine is adequate.
Wash the udder with a clean towel	Stimulates milk let-down and release of the hormone oxytocin which acts on the milk secretory (alveolar) cells, causing release of milk.
Remove the fore milk into a strip cup	Helps to check for abnormal colour or presence of blood clots. This may indicate infections like mastitis. The fore milk should be discarded.
Complete milking within 4–5 minutes	After 5 minutes, the stimulation effect of release of oxytocin wanes away.
Dip teats in a post teat dip disinfectant (iodophor or hypochlorite)	Prevents infection of the udder.
Test cows regularly using the California mastitis test (CMT) or the Whiteside test, both of which are simple to use.	Enables early detection and treatment of mastitis



Figure 2.4: Udder preparation should not take more than one minute

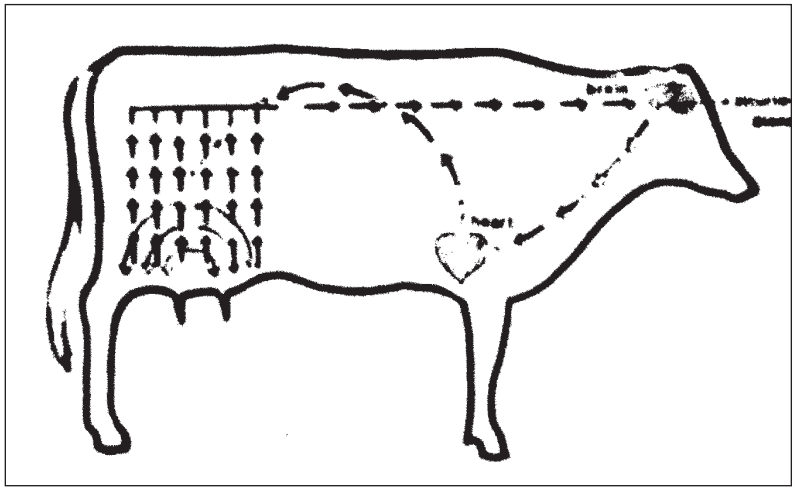


Figure 2.5: Washing the udder stimulates milk let down

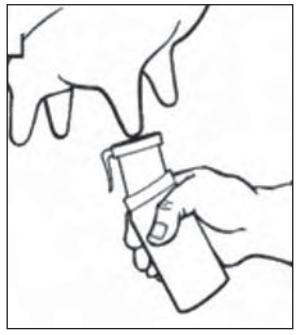


Figure 2.6: After milking, dip teats in disinfectant

2.5 Use of appropriate equipment

One of the major sources of contamination of milk is the use of equipment and storage vessels which cannot be easily cleaned and sanitised. These include jerry cans and buckets made of non-foodgrade plastic. Metal containers such as aluminium and stainless steel cans are recommended under the code of hygienic practices.

2.6 Practical exercise in hand milking and mastitis control

Objectives

The objectives of this three-hour practical exercise are to enable participants:

- learn how to milk a cow hygienically
- test for and identify cows with clinical or sub-clinical mastitis

Materials required

- A group of 10 to 20 milking cows. (It would be useful to have at least one cow with known clinical mastitis)
- Milking buckets
- Clean towels (one per participant)
- One strip cup
- One or two CMT paddles
- CMT reagent
- Post teat dip chemical
- Warm water
- Hypochlorite udder disinfectant (80–150 ppm)
- Two 250 ml sterilised conical flasks (one for foremilk and one for strippings)
- Record form

Procedure

1. Pour tepid water into a bucket and add adequate sodium hypochlorite solution until the water has a distinct smell of chlorine.
2. Select one of the milking cows and lead her to the milking cubicle.
3. Wash the udder with a clean towel and tepid water, followed by chlorinated water.
4. Dry the udder with a clean towel.
5. Squeeze a few strips of milk onto the black surface of the strip cup. Examine the milk for any clots or blood stains. Presence of clots or blood indicates the cow is suffering from mastitis. Discard the milk in the 250 ml conical flask labelled "foremilk".
6. If there are no clots or blood stains in the milk, proceed with the next step.
7. Take a CMT paddle and squeeze a few squirts of milk from each quarter of the udder into each compartment, labelled A, B, C and D.
8. Record your observations on the provided form.
9. Take a clean, dry bucket and start milking by squeezing and releasing the teats. Follow the demonstration given by an experienced milker.
10. Cool the milk by placing the milk can in one of the available cooling facilities at the farm.
11. Examine the quality of the milk after six hours (for morning milk) or the following morning (for evening milk) by performing clot-on-boiling, alcohol and acidity tests. Also analyse the butterfat content and total plate count of the foremilk and strippings.
12. Record your results on the form provided and discuss them with the instructor.



Mastitis test record form

Cow no.	Lactation no.	Days in lactation	Fore milk clot		CMT test result			
			+	–	Q1	Q2	Q3	Q4

Key for CMT mastitis test:

-	Negative
+	Slightly positive
++	Positive
+++	Very positive

CHAPTER

3

Quality assurance in milk collection by farmer groups

3.1 Understanding the nature of milk

Small-scale milk producers very often form associations, self-help groups or co-operative societies in order to market their milk more efficiently by pooling their resources and the small quantities of milk each of them produces. Depending on the type and intensity of the dairy production system, between 50 and 200 farmers are needed to operate a cooling centre that receives 100–2000 litres of milk. In the previous chapter, the techniques to be followed by individual farmers in the production of clean milk have been elaborated. However, even when attempts are made by every farmer in the group to follow guidelines for clean milk production, there will still be day-to-day variations in the quality of milk produced by individual farmers and between different farmers. Hence it is important for milk producers to understand the factors that influence the difference in milk composition and quality so that measures can be taken at the farm level to minimise these variations.

3.1.1 Characteristics of milk

Normal whole milk contains a balanced proportion of milk fat (4 per cent), lactose (4.8 per cent), proteins (3.5 per cent), minerals (0.7 per cent), vitamins and other minor constituents such as enzymes and hormones. The pH of normal raw milk is about neutral (pH 6.7) with a corresponding titratable acidity of 0.16-0.17 per cent due to the natural buffering capacity of milk proteins and salts. The density ranges from 1.026 to 1.032 g/ml. Wholesome milk should contain only a few bacteria and no extraneous matter, if it has been produced hygienically. Depending on how milk is handled during and after milking, the natural composition and physico-chemical properties of raw milk may change.



3.1.2 Effect of milking practices

Incomplete milking results in low milk yield and low fat content because the last milk (strippings) contains more fat than the foremilk. Changing the milking interval will also interfere with the composition and yield of the milk. Poor hygiene will result in milk with high numbers of spoilage microbes.

3.1.3 Stage of lactation

Immediately after calving, a cow produces colostrum during the first five days after which the milk reverts to its normal composition. Colostrum is heavier than normal milk and contains 10 times more whey proteins. Colostrum is also more alkaline (pH 6.8–6.9) than normal milk. Hence, only the milk produced after five days from calving should be sold.

3.1.4 Effect of mastitis

On farms practicing good husbandry, 20 to 30 per cent of lactating cows have one or more quarters infected with sub-clinical mastitis. With poor hygiene, up to 70–80 per cent of the cows may be affected. The composition of mastitis milk approaches that of blood. It has more whey proteins, less casein and less water-soluble vitamins. It also tends to be more alkaline, has a higher chloride content than normal milk, and tastes salty like the milk of very old cows (more than six lactations) or milk of cows in late lactation (near drying off).

3.1.5 Effect of feeding

Cows have to be properly fed to produce a high volume of milk of good composition. If cows are fed a diet low in forages and high in starch, the butterfat content of the milk may fall below 2.5 per cent. A good forage-to-concentrate ratio is important to enable cows produce good quality milk to their potential.

3.1.6 Effect of storage temperature

If raw milk is not cooled soon after milking, the inherent lactic bacteria will multiply within two to three hours, converting lactose into lactic acid and causing the milk to start souring. Such milk is unsuitable for processing and will be rejected at milk collection centres and processing plants. If the milk is overly sour, it will be

unacceptable to milk collection centres, processors as well as buyers of raw milk who invariably boil their milk before drinking it. Raw milk with high levels of acidity will also have high numbers of bacteria. Such milk will be rejected or down-graded at milk collection centres or by processors.

3.1.7 Effect of cold storage

Cooling milk delays the multiplication of bacteria, except for a few cold-tolerant bacteria (psychrotrophs) which can grow at refrigeration temperatures. If milk is kept chilled at 4°C for more than 72 hours, the cold-tolerant bacteria will multiply and produce lipase and protease enzymes that, respectively, break down milk fat and proteins. These enzymes are also heat resistant, and can cause spoilage of pasteurised milk and other processed dairy products. Extended cooling also makes calcium in the milk less soluble and unavailable during coagulation of milk by rennet in cheese making. The milk has to be warmed to about 60°C (thermisation) to reverse this problem.

3.1.8 Effect of heating

Pasteurisation of milk involves heating it to 63°C for 30 minutes or 72°C for 15 seconds in order to destroy harmful microorganisms. Pasteurisation kills more than 90 per cent of bacteria and causes minor denaturation of proteins and loss of some water-soluble vitamins. Heating milk above 90°C causes more than 65 per cent denaturation of whey proteins. Both pasteurisation and boiling of milk cause calcium to become insoluble and unavailable in coagulation of milk by rennet. Hence to get a good coagulum, addition of calcium chloride at the rate of 20 g /100 litres is sometimes recommended to restore the balance of calcium ions. Both pasteurisation and boiling destroy the milk enzyme phosphatase. However, the enzyme peroxidase is not destroyed by pasteurisation but is destroyed by heating milk to over 80°C. Hence the phosphatase test is used to measure whether or not milk has been adequately pasteurised while the peroxidase test measures whether or not milk has been heated to over 80°C (see Appendix 1 for details of the two tests).

3.1.9 Effect of adulteration

Adulteration of milk by intentional addition of water or other substances (e.g. margarine, coconut milk, cassava flour) is a common problem in many developing countries. Adulteration is illegal because it alters the natural composition of milk and can introduce harmful bacteria and other dangerous substances into milk. Water adulteration lowers the specific gravity and increases the freezing point of milk; normal whole milk has specific gravity range of 1.026 to 1.032 while its freezing point is minus 0.54°C. Hence, milk collection centres and processors routinely determine the specific gravity of raw milk and reject milk suspected of having been adulterated.

3.1.10 Effect of treatment of cows with antibiotics

When cows suffer from mastitis they are treated with antibiotics by intra-mammary or intramuscular injection. The antibiotics circulate in the blood and are secreted in the milk for up to 72 hours. Longer acting (slow release) antibiotics, such as are used in dry cow therapy against mastitis, remain in the blood longer. Drug residues in milk are undesirable because they can trigger allergies and drug resistance in humans, and inhibit the lactic acid starter cultures used in the manufacture of fermented milk products. For this reason, milk processors routinely screen raw milk for antibiotic residues (see Appendix 1). It is important for farmers to adhere to the specified withdrawal periods and follow the advice of a qualified veterinarian on when to resume sale of milk after antibiotic treatment of cows.

3.2 Quality assurance during transportation of milk

Vessels used to transport milk must meet the specifications in the code of hygienic practices. Vessels made of copper or copper alloys should not be used for milk as copper oxidises butterfat, resulting in off-flavours. Aluminium and stainless steel containers are ideal. Non-foodgrade plastic cans, buckets and jerry cans must not be used[1]. In addition to milk vessels being made of the right material they should:

- Have smooth finishes free from open seams, cracks and rust

[1]*Note: A code of hygienic practices in your country will specify requirements for milk handling equipment. These should be followed in training of farmers, transporters and small scale processors.*

- Have wide openings such that every surface that comes into contact with milk can be accessed easily for cleaning and sanitation. In this regard, both metal and plastic containers with dead ends should not be used for handling and storage of milk.
- Be used only for handling and storing milk

3.3 Quality assurance at milk collection centres

Farmer groups and operators of milk collection points and centres need systems of quality control for the milk they receive from individual farmers. This enables segregation of poor quality milk at collection centres. Several simple tests, if carried out judiciously and consistently, will enable the milk collection centre to ensure that only good quality milk is accepted for onward transportation to milk processing factories, milk bars or retailers of raw milk in urban centres. The following tests can be carried out at the collection centre or dairy processing factory.

3.3.1 Organoleptic test

This is the simplest test as it requires only the use of the senses of smell and sight. Milk which contains objectionable smells or particles or has an abnormal colour can easily be detected. The milk grader must have a good sense of sight, smell and taste. The organoleptic test should be the first test to be carried out on all milk received at the collection centre and poor quality milk should be immediately rejected, obviating the need to proceed with other quality control tests.

Procedure

- Open a can of milk.
- Immediately smell the milk and establish the nature and intensity of smell, if any. If the milk has foreign odours (e.g. smoky, burnt, weedy, chemical/drug smell) or smells sour, it should be rejected.
- Observe the appearance of the milk (colour of the milk, any marked separation of fat, colour and physical state of the fat, foreign particles or physical dirt).
- Check the cleanliness of the milk can and lid.



- If still unable to make a clear judgement, taste the milk but do not swallow it. Spit out the milk you have tasted into a bucket provided for that purpose or drain basin and flush with water.
- Touch the milk container to feel whether it is warm or cold. This will enable you to know whether or not the milk has been cooled since this will also influence the lactometer reading.

Interpretation of results

Abnormal appearance or smell in the milk may be caused by:

- Advanced acidification or souring
- Chemical or drug taints or discolouration
- Type of feed or atmospheric taint
- Boiling of milk
- Presence of smoke
- Bacterial taints
- Spontaneous rancidity of milk from cows in late lactation
- Oxidation due to the presence of heavy metals (e.g. copper) and exposure to light

Marked separation of milk fat may be caused by:

- Milk previously chilled and subjected to excessive agitation during transportation
- Previous freezing and thawing of the milk (check temperature as well)
- Adulteration by other solids (may also show as sediments or particles)
- Boiling, if milk fat is hardened



3.3.2 Clot-on-boiling test

This test is quick and simple. It allows you to reject milk that has developed high acidity or colostral milk that has a very high percentage of whey proteins, which do not withstand heating at high temperatures.

Materials

A test tube or spoon

A paraffin burner or Bunsen burner

Procedure

Boil a small amount of milk in a spoon or test tube. If there is clotting, coagulation or precipitation, the milk has failed the test and should be rejected.



Figure 3.1: Carrying out the clot-on-boiling test

3.3.3 Alcohol test

Principle of the method

The stability of casein in milk depends partly on the degree of hydration of the casein particles. Development of acidity in milk causes partial dehydration of the casein micelles. When acid levels are high enough, the addition of an equal amount of 68 per cent alcohol to milk will lead to further dehydration and destabilisation of casein and cause the milk to clot. The alcohol test can detect milk whose pH is 6.4 or lower and is more sensitive than the clot-on-boiling test which only detects milk pH levels of 5.8 and below. Colostrum and mastitis milk may give a positive alcohol test.

Materials and equipment

Depending on the specific environment and facilities available, the following can be used:

- Test tube (10 ml) or small beaker (25 ml)
- 2 ml pipette or dispenser or syringe for drawing alcohol

- 2 ml pipette or syringe for drawing milk
- 68 per cent alcohol. This is prepared by mixing 68 ml of 96 per cent (absolute) alcohol and 28 ml of distilled water.

Procedure

Draw two ml of the milk sample into the test tube or small beaker. Add two ml of the 68 per cent alcohol. Mix well and observe for any flocculation. If the test sample is of good quality, there will be no coagulation, clotting or precipitation, but is important to look for small lumps. You may also use an alcohol gun when testing samples from many farmers.



Figure 3.2: Carrying out the alcohol test

Interpretation

Milk will flocculate when the pH reaches around 6.4 or a titratable acidity of 0.21–0.23 per cent lactic acid. Acidity may be determined by titration with an alkali (see Appendix 1: Section 2). If the tested milk sample coagulates, clots or precipitates, it will have failed the test and the milk should be rejected. Because this test is quite sensitive, milk that passes this test can keep for some hours before it goes bad. Always carry some water for rinsing the syringe between samples.

3.3.4 Alcohol–alizarin test (Alizarol test)

The procedure for carrying out this test is the same as for the alcohol test but this test gives more information on the quality of the raw milk. Alizarin is an indicator which changes colour according to the level of acidity. The alcohol-alizarin solution can be bought ready-made or may be prepared by adding 0.4 g alizarin to one litre of the 68 per cent alcohol solution. The advantage is that it will indicate whether the flocculation is due to mastitis milk if the colour turns lilac as well.

Table 3.1: Interpretation of Alizarol test

Parameter	Normal milk	Slightly acidic milk	Strongly acidic milk	Alkaline milk
pH	6.6–6.7	6.4–6.5	6.3 or lower	6.8 or higher
Colour	Red brown	Yellowish-brown	Yellowish	Lilac
Appearance of milk	No coagulation; no lumps	No coagulation	Coagulation*	Coagulation**

*Yellowish in colour with small lumps or completely coagulated

**Lilac in colour; clots and flakes indicate mastitis milk.

3.3.5 *Lactometer test*

Principle of the method

This test is used to check if milk has been adulterated with added water or solids. The test is based on the fact that the density of whole milk ranges from 1.026 to 1.032 g/ml. Adding water to milk lowers its density, while addition of solids increases the density of milk. A lactometer is the equipment that is used to measure the density of milk, and any deviation from the normal range would indicate that the milk has been adulterated. When this test is carried out together with the Gerber butterfat test (see Appendix 1), the content of total solids and solids-not-fat (SNF) can be calculated. According to the food standards in many countries, the minimum acceptable SNF content and density for whole milk is 8.5 per cent and 1.026 g/ml, respectively.

Materials

Measuring cylinder (200–250 ml)

Lactometer calibrated at 20°C (European standard) or 27°C (India Standard)

Procedure

Ensure that the milk has been left to cool at room temperature for at least 30 minutes and its temperature is about 20°C. If the milk was cooled below 10°C, warm it to 40°C, and then cool it to 20°C. Mix the milk sample and pour it gently into the measuring cylinder. Then let the lactometer sink slowly into the milk. Take the lactometer reading just above the surface of the milk.

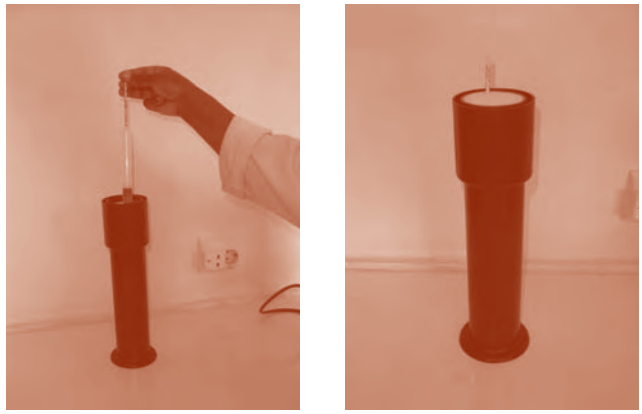


Figure 3.3: The lactometer test

Interpretation

If the temperature of the milk is different from the calibration temperature of the lactometer (20 °C), then use this correction factor: For each °C above the calibration temperature, add 0.2 units to the observed lactometer reading and for each °C below the calibration temperature, subtract 0.2 units from the observed lactometer reading. These calculations are done on the lactometer readings, e.g. 29 instead of the true density of 1.029 g/ml.

Normal milk has specific gravity of 1.026–1.032 g/ml (or 26–32 on the lactometer reading). If water has been added, the lactometer reading will be below 26. If any solid such as flour has been added, the reading will be above 32.

Table 3.2: Lactometer reading correction for lactometer calibrated at 20ºC

Milk temperature	Observed lactometer reading	Correction	Corrected lactometer reading
17°C	30.6	-0.6	30
20°C	30.0	NIL	30
23°C	29.4	+0.6	30

A more accurate method for testing for adulteration of milk with water is to measure the freezing point. Normal whole milk has a freezing point of –0.54°C. Water adulteration raises the freezing point of milk closer to that of water (0°C), depending on amount of water added (See Appendix 1: Section 6).

Where laboratory facilities are available, the following additional tests can be carried out.

- Freezing point determination using cryoscopy apparatus
- Butterfat test (Gerber or Babcock method)
- Inhibitor test (For antibiotic drug residues)

The details of these tests are given in Appendix 1. The instructor will arrange which tests you can carry out, depending on resources available at the training venue.

3.3.6 Cleaning and sanitation of equipment

It is necessary to provide a facility for cleaning of milk cans and other vessels used in bringing the milk to the milk cooling centre. A wash trough with cold running water will enable milk cans to be rinsed free of milk immediately they are emptied. Soap for cleaning milk cans should be made available by the farmer group. Milk cans should be well rinsed after cleaning to avoid tainting the milk with soap residues.

Farmers should be advised to thoroughly clean their milk cans with soap and tepid water immediately upon returning to the farm. A final rinse with hot water will kill most bacteria. The cans should then be dried on a drying rack in the sun; sunlight helps in killing harmful bacteria.



Figure 3.4: Air-drying of milk cans after cleaning and sanitation

CHAPTER

4

Hygienic milk handling by small-scale traders and transporters

4.1 The perishable nature of milk

Transportation of milk constitutes a vital link between producers and consumers in the milk marketing chain. In an industry that is dominated by the informal sector, this function is carried out by thousands of itinerant milk traders and some specialised transporters. Given that milk is a very perishable product, milk transporters need to understand the need to observe high standards of hygiene, speedy transport and careful handling of milk. These basic requirements are necessary to minimise losses due to milk spoilage, avoid contamination of milk by pathogens and ensure a profitable milk transportation business.



Figure 4.1: Transporting milk by bicycle

Here are some factors that can influence the quality of milk before and during transportation:

- **Type of breed.** Dairy cows with high milk yields, such as Friesians, produce milk with lower fat content than lower yielding breeds such as Jerseys or local zebu cattle.
- **Contamination.** Use of dirty vessels will increase the bacterial load of milk and shorten its shelf life. Hence it is important to use only very clean milk cans and other vessels, and to keep the milk covered at all times during transportation.

- **Storage temperature.** The higher the temperature, the faster bacteria will grow and cause the milk to sour. Chilled milk must be maintained at low temperatures during transport by using insulated containers or boxes, or transporting milk on ice where possible.



Figure 4.2: Transporting milk in an open pick-up vehicle

- **Time since milking.** Where milk is collected uncooled, the time elapsed since milking is very crucial. Milk will naturally resist bacterial multiplication within the first couple of hours. Thereafter, bacteria will multiply very fast, doubling every 20 to 30 minutes. Hence, the secret to a successful milk transport business involving unchilled milk is to ensure that milk is transported within a maximum of three hours since milking. The distance covered within this time limit will be short if transporting milk on foot, slightly longer if using a bicycle and up to 50 km or more if using a vehicle or motorcycle on a good road.
- **Exposure to light.** Milk is very sensitive to light. Prolonged exposure of milk to light or ultraviolet radiation can lead to undesirable oxidised flavours due to oxidation of light-sensitive vitamins (riboflavin and vitamin C) and butterfat.
- **Chemical contamination.** Contamination of milk with chemical compounds results in off odours and taints. Chemical contamination and taints from animal feeds, barn odours, kerosene, smoke and tobacco can lower the quality of raw milk so it is important to avoid exposing milk to these elements. Antibiotic drug residues from cows undergoing treatment should be avoided by adhering to the specified withdrawal periods. Milk transporters need to check with their suppliers on the status of exposure of the milking cows to these elements in case of any abnormal milk odour.
- **Excessive agitation.** When milk is agitated, the milk fat is destabilised and becomes easily oxidised. Avoid excessive agitation such as may be caused by transporting half-full cans.

The code of hygiene spells out specific requirements that have to be met by milk transporters. These are briefly discussed below.

4.2 Hygienic cleaning and sanitation procedure

A very important item of the milk transport business is the vessel in which the milk is carried. Such vessels should satisfy the requirements outlined under section 3.2. In addition, all milk handling vessels should be washed and disinfected immediately after use as follows:

- Pre-rinse with clean potable water
- Thoroughly scrub the container with warm water and detergent/soap using a suitable brush or scouring pad (do not use steel wool or sand!)
- Rinse the container with clean running water
- Immerse the container in boiling water for at least one minute
- Sun dry the container upside down on a drying rack

4.3 Personal hygiene

All persons handling milk should maintain high levels of personal hygiene. A milk transporter or handler should:

- wash hands and nails with clean water and soap before handling milk
- wear clean overalls/dust coat and gum boots while handling milk
- not be suffering from a communicable disease or have open sores or abscess on the arms, hands, head or neck
- not cough or sneeze over milk or milk containers
- bathe or shower regularly



Figure 4.3: Wash hands with clean water and soap

4.4 Quality assurance by milk traders and transporters

Because raw milk is highly perishable, traders and transporters must take care during handling to avoid spoilage of milk which would result in it being rejected at processing factories or by consumers. Generally, in order for a milk transport business to be profitable, losses due to spoilage, spillage or wastage must be kept below five per cent of the total volume of milk handled.

Here are some points to observe that will assist in assuring the quality of milk handled by traders and transporters:

Test the quality of the milk you collect so that only good quality milk is received

The following basic quality control tests can be carried out:

- Organoleptic test
- Alcohol test
- Measurement of milk temperature
- Measurement of milk density (lactometer test)

The tests are described in detail in Chapter 3. It is important for milk traders and transporters to acquire the knowledge and skills needed to carry out these tests accurately.



Figure 4.4 Test the quality of milk immediately it is received

To maintain the quality of milk during transportation, adhere to the following guidelines:

- Ensure that milk containers and the transport vehicle are kept clean.
- Do not use milk containers for storage of other goods.

- Do not transport milk with other goods. The code of hygiene requires that vessels and carriers used for milk transport should be used only for that purpose and be labelled “MILK ONLY”.
- Keep the milk as cool as possible and avoid exposing it to high temperatures.
- Keep the milk covered at all times to protect it from light and dust.
- Transport the milk to the sales point or processing factory in the shortest time possible.
- Do not smoke, handle tobacco or other materials with strong odour (e.g. kerosene fuel) when handling milk.
- Avoid excessive agitation of the milk cans.

CHAPTER

5

Appropriate technologies for small-scale processing of milk and dairy products

5.1 Liquid milk

Heating of milk at 63°C for 30 minutes in batch pasteurisers or 72°C for 15 seconds has been used for more than 100 years as a way of making milk safe for human consumption. In developed countries, pasteurisation is mandatory for all liquid milk intended for sale to the public. In Africa, where the dairy industry is relatively less developed, more than 80 per cent of marketed milk is sold raw. Because they realise the danger of consuming raw milk, most consumers who buy raw milk boil it before consumption thereby eliminating any public health risks.



Figure 5.1: Open pan boiling of milk is both unhygienic and inefficient. Photo by David Balikowa

Bulk quantities of milk are usually boiled using direct open pan heating (Figure 5.1). This leads to burning of the milk on the surface of the container due to the high temperature at the point of contact. Using simple equipment, this traditional procedure can be modified to ensure moderate heating of the milk which preserves both its organoleptic and nutritional quality.

5.1.1 Milk pasteurisation by indirect heating



Figure 5.2: Heating milk in an insulated water bath is more hygienic and energy-efficient than open pan boiling. Photo by David Balikowa

The simplest form of batch pasteurising milk is indirect heating of milk in a can placed in a larger metal container containing water which is heated by an open flame or placed on an electrically heated hot plate. The water forms a jacket around the milk can. The milk is heated to at least 63°C with frequent stirring to ensure uniform heating. The can is taken out of the hot water and placed in a basin or trough containing cool water. The cool milk may then be packaged in plastic sachets. The disadvantage of this method is the danger of recontamination during filling of the plastic sachets or bottles. To minimise recontamination, "hot-filling" may be done at 55–60°C and the final cooling takes place in the sealed plastic sachet. This simple technology is being successfully used by small-scale processors handling less than 300 litres of milk per day. One small-scale processor in Dar es Salaam, Tanzania has used this type of technology for processing up to 1500 litres of milk per day by using a water tank that holds 4-6 cans per batch.

5.1.2 In-pouch pasteurisation



Figure 5.3: Filling milk in sachets before in-pouch pasteurisation

An alternative to "in-can" batch pasteurisation is heating sealed sachets in a hot water bath or "in-pouch" pasteuriser. The system consists of sachet filler / sealer, a thermostatically controlled water bath capable of accommodating 80–150 litres of milk in sachets and an ice bank for chilled water in which the sachets are cooled after pasteurisation.

5.1.3 Practical exercise

Quality control during pasteurisation is aimed at ensuring that the processing temperature-time combination has been maintained so that the milk is adequately pasteurised and not subjected to over-heating.

Objectives

The objectives of this exercise are to:

- Introduce trainees to basic elements of quality control of pasteurised milk
- Enable trainees perform simple tests for identifying milk that has been heated to varying intensities.

Phosphatase test

The phosphatase test measures the efficiency of milk pasteurisation. Phosphatase is an enzyme in milk which is inactivated by pasteurisation temperatures. The presence of phosphatase in pasteurised milk indicates that pasteurisation was inefficient and therefore some risk of infection with milk-borne pathogens still exists. The procedure for carrying out the phosphatase test is described in Appendix 1. It takes three hours to complete so it should be carried out on pasteurised milk only if there is adequate time to complete the exercise.

Peroxidase test

The peroxidase test measures whether milk was over-heated during pasteurisation. Peroxidase enzyme is more heat resistant than phosphatase and is not inactivated by pasteurisation. Thus, the absence of peroxidase in pasteurised milk implies over-heating or boiling of the milk above 75°C. The test can be used by milk processors to identify evening milk which was previously boiled and is being delivered under the guise of being fresh raw milk. Previously boiled milk may also be detected by smelling or tasting the milk. The procedure for carrying out the peroxidase test is described in Appendix 1.

Turbidity test

The turbidity test detects the freshness of milk. Boiling or sterilising (heating at 100–115°C for up to 20 minutes) milk denatures the whey proteins, which will subsequently not form a precipitate when reacted with ammonium sulphate. The turbidity test is carried out by adding 20 ml of milk in a conical flask containing 4 g ammonium sulphate. The milk curdles. Filter through Whatman No. 40 filter paper into a clean test tube. Heat the filtrate in a boiling water bath. Presence of a precipitate indicates a positive turbidity test and shows that the milk is fresh. Ultra-heat treated (UHT) milk may give a positive turbidity test, depending on whether it was directly or indirectly heated with steam.

5.2 Cream

Butterfat is one of the most valued components of milk. It gives milk its special creamy taste and colour. It is also the basis for the manufacture of a number of fat-rich products such as cream, butter, butter oil and ghee. Butterfat is present in milk in low concentration of 3.2–5.5 per cent depending on the breed. Milk of Zebu cattle and water buffaloes can contain as much as 5–6 per cent and 6–8 per cent butterfat, respectively. In order to concentrate it, the butterfat must be separated from the milk serum. Butterfat is lighter than milk serum and so it easily rises to the surface of milk if left undisturbed for some time. This gravitational separation formed the basis of early creameries before the invention of the centrifugal cream separator during the 1880s. The invention of the cream separator spurred the development of the dairy industry in Europe and America. It is noteworthy that the first dairy processing factories were creameries specialising in cream separation and butter making. In Africa, smallholder farmers and traditional pastoralists still obtain cream through natural, gravitational separation and butter through churning of sour milk.

5.2.1 Gravitational cream separation: overview

It is well known that when milk is left undisturbed in a container, a layer of cream forms at the top within a few minutes. It is therefore not surprising that the first commercial separation of cream was based on gravitational separation. Following is the principle governing gravitational separation.

Principle of gravitational separation

We know that when soil is mixed with water and left undisturbed, the heavier particles begin to settle at the bottom followed by less heavier material and so on until you have clear water at the top. The heavier material displaces the lighter material at the bottom while the lighter particles rise through the body of water, which is the continuous phase. Similarly in milk, fat globules are dispersed in the milk serum containing milk proteins, sugar and minerals. Milk is thus an oil-in-water (o/w) emulsion in which the milk fat globules form the disperse phase and the milk serum the continuous phase. Left undisturbed, and under the influence of gravitational force, the lighter fat is quickly displaced from the bottom by the heavier milk serum and the individual fat globules rise to the top to form a cream layer. The rate of rise (V) is determined by Stokes' Law which governs the rate of settling of spherical particles in a liquid.

$$V_m = \frac{d^2 (\rho_1 - \rho_2) g}{18\eta}$$

Where:

V_m = terminal velocity of an individual fat globule (m/s)

d = diameter of fat globule (m)

ρ_1 = density of the liquid phase (kg/m^3)

ρ_2 = density of the particle (kg/m^3)

g = acceleration due to gravity (m/s^2)

η = specific viscosity of the liquid phase (kg/m.s)

Interpretation of the equation reveals the following:

The rate of sedimentation is faster:

- the greater the difference between the density of the milk serum (ρ_1) and the fat globules (ρ_2)
- the bigger the particle diameter and
- the lower the viscosity of the milk serum

Therefore, any factor which influences the three parameters positively will also influence the rate at which fat globules rise to form a cream layer. These factors include temperature, fat globule size and viscosity of the milk serum.

Effect of temperature

Increasing the temperature of milk improves the efficiency of cream separation. Maximum efficiency of cream separation is attained at 32–38°C. Temperatures greater than 38°C lead to heavier cream but the separation efficiency, i.e. the proportion of milk fat recovered from the milk, is lower and a high proportion of the fat remains in the skim milk. Above 60°C, agglutinin–a lipoprotein that binds fat globules–is destroyed, thus milk that is boiled or heated above 100°C retains very little creaming ability as the cream layer becomes entrapped in denatured whey proteins. The cream layer of such severely heated milk therefore contains both denatured proteins and milk fat, and is thicker and heavier than normal cream.

Effect of fat globule size

Larger fat globules rise faster, and on the way collide and agglutinate with smaller globules, thereby becoming larger and rising further to the surface, forming clusters as they approach the surface and eventually a cream layer. Agglutinin facilitates the formation of fat clusters.

Effect of agitation

Excessive agitation disrupts cluster formation by breaking up any clusters.

Effect of homogenisation

Homogenisation breaks the fat globules to less than 1 mm in diameter, thus homogenised milk will not form a cream layer due to the small size of the fat globules.

5.2.2 Gravitational cream separation: methods

Shallow pan method

The earliest method used to separate cream from milk was the shallow pan method designed to make the path (distance) the fat globules have to travel as short as possible. Separation was done in shallow pans 15–24" wide x 4" deep (Figure 5.4)

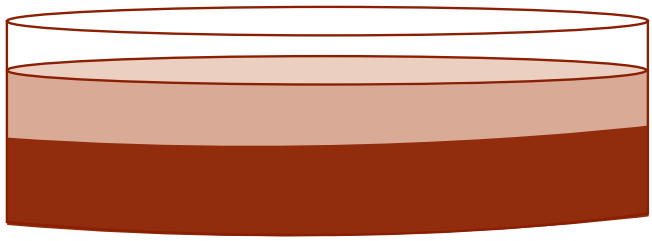


Figure 5.4: Shallow pan gravitational separator (Adapted from Kurwijila, 2005)

A cream layer forms in 24–36 hours. Because the cream separation takes place at ambient temperature, both the cream and skim milk become sour and cannot be pasteurised. Although this method is simple and cheap, the main drawback is that it takes a long time for the cream layer to form, and the cream cannot be used in standardising liquid milk. The sour skim milk can, however, be used to make cottage cheese such as *ayib* of Ethiopia. Sour cream can easily be converted to sour butter and eventually ghee.

Deep setting method

The deep setting method was designed to maximise fat cluster formation under low temperature and slow down acidification of the milk. The separation vessel is 8–20" deep. The vessel is placed in cool running water at 10°C. A cream layer of about 20 per cent butterfat is formed in 24 hours. The skim milk has about 0.2–0.4 per cent butterfat. The cream may or may not sour depending on the initial bacterial load and temperature of the raw milk. Skim milk is drawn at a faucet at the

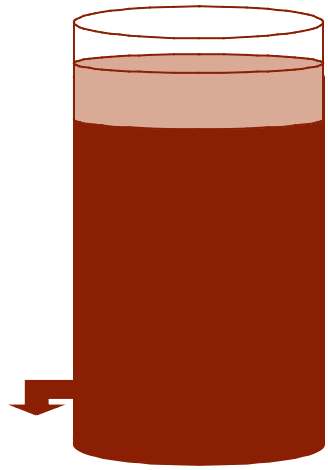


Figure 5.5: Deep setting gravitational separator (Adapted from Kurwijila, 2005)

bottom of the vessel. Drawbacks include the long time required to make cream and the fact that very large quantities of cream cannot be separated using this method.

5.2.3 Centrifugal cream separation

A Swedish inventor, Carl Gustaf Patrik de Laval, invented the continuous centrifugal cream separator in 1877. It quickly replaced the inefficient gravitational methods of cream separation. The mechanics of the centrifugal separator are also based on Stokes' Law. However, instead of relying on gravitational force, the centrifugal force generated by rotating conical discs around a central spindle effects the separation of butterfat from the milk serum instantaneously. Depending on the speed of rotation and the diameter of the centrifugal field, the centrifugal force in a cream separator can be 500–10,000 times greater than the gravitational force.

The centrifugal separator

The centrifugal cream separator consists of 19–120 discs stacked together at an angle of 45–60 degress with a 0.4 to 2.0 mm gap between them to form a separation channel. Each conical disc has a distribution hole. Once the discs are assembled together to form a separator bowl, the holes form a vertically aligned distribution channel through which milk is introduced at the outer edge of the separator bowl. (Figure 5.6).

The bowl may be rotated manually or by an electric motor. In either case, when milk is fed into the rotating separator bowl through the central distributor shaft, the heavier skim milk is forced outwards towards the

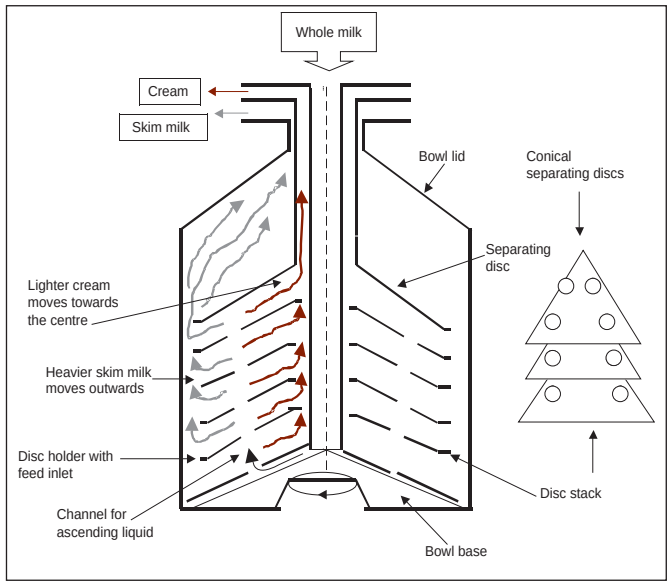


Figure 5.6 Milk flow through a separator (Adapted from Kurwijila, 2005)

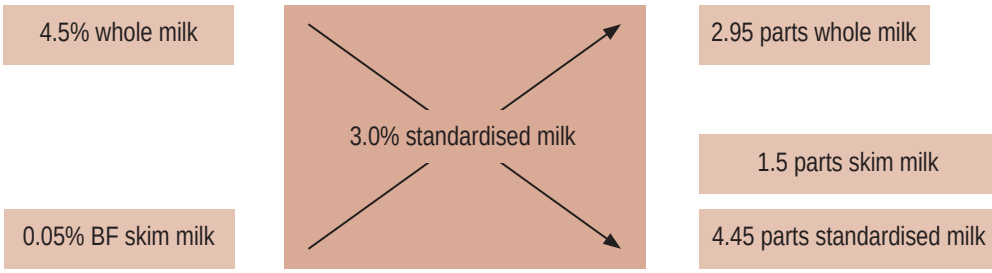
periphery while the lighter cream is displaced towards the axis of rotation through the separator disc holes. The cream and skim milk are drawn through separate outlet spouts. The speed of rotation can vary from 2000 revolutions per minute (rpm) in small manual separators to 20,000 rpm in large electric cream separators.



Figure 5.7: Hand cream separators are ideal for rural based small-scale processing units (source: Kurwijila, 2005)

5.2.4 Milk standardisation

The separation of cream from skim milk by centrifugal separation makes it possible to utilise various milk components more efficiently and to increase profits by making other products such as butter and ghee which fetch higher prices. Additionally, fermented milks and cheese can be processed from milk whose butterfat content has been standardised to a specific level. Standardisation calculations can be done by using the Pearson square method as shown below.



Every 100 parts of milk standardised to 3% butterfat (BF) will require (2.95/4.45)100 = 66.3 parts whole milk containing 4.5% BF and (1.5/4.45)100 = 31.6 parts skim milk containing 0.05% BF. Hence, 300 litres of milk standardised to 3% butterfat will be obtained by mixing 198.9 litres whole milk (300 x 66.3/100) and 101.1 litres skim milk.

In large dairies, the standardisation is done automatically by using cream separators with valve adjustments that allow remixing of the cream and skim milk in proportions that give standardised milk with a desired level of butterfat content. In the above example, the ratio 1.97 parts whole milk to 1 part skim milk will give 2.97 parts of standardised milk containing 3% butterfat.

5.2.5 Standards for cream

By definition, "cream" must have a minimum of 18 per cent butterfat while "double cream" must have 30–40 per cent butterfat. Centrifugal cream separators are designed to give cream of 30–50 per cent butterfat and skim milk containing not more than 0.05–0.07 per cent butterfat. Higher levels of butterfat in the skimmed milk will reduce the efficiency of cream separation. The fat content in the cream can be varied by adjusting the throughput of the milk, or the cream screw in manual cream separators, or the out valves for cream and skim milk in electric cream separators. Cream separators can yield cream with 70 per cent butterfat, which can then be standardised with skim milk to obtain cream of the required fat content. Automatic standardisation is also possible depending on the design of the cream separator. Various countries have set standards for butterfat content for different types of cream (Table 5.1).

Table 5.1: Standards of butterfat content for different types of cream

Type of cream	Per cent butterfat	Use of cream
Half cream	10–18	Coffee cream
Whipping cream	28–35	Table cream
Heavy whipping cream	>35	Table cream
Double cream	>45	Ice cream

5.2.6 Practical exercise

The objective of the exercise is to enable you to know how to:

- assemble and disassemble a cream separator
- separate cream from milk
- standardise a sample of milk to 3% butterfat content
- determine the butterfat content in milk

Materials required

- Raw whole milk (30–50 litres)
- Hand cream separator
- Butterfat analysis equipment (See Appendix 1, Section 4)

Procedure

1. Sample 10 ml of raw whole milk (see Appendix 1 for procedure of milk sampling).
2. Determine the per cent butterfat content of the whole milk, according to the procedure in Appendix 1.
3. Set aside 7-8 litres of whole milk and use the rest to prepare skim milk.
4. Determine the butterfat content of the skim milk.
5. Use the Pearson square method to calculate the amounts of whole and skim milk needed in order to obtain 10 litres of milk standardised at 3% butterfat.
6. Standardise the whole milk according to the calculated proportions.
7. Sample 10 ml of the standardised milk and determine the butterfat content.
8. Compare the measured butterfat content with the theoretical value of 3% and explain any differences.

5.3 Butter

Butter is obtained by concentrating the butterfat in milk into a spread containing 80 per cent fat, 16 per cent moisture, 2 per cent SNF and up to 2 per cent salt. Butter may also remain unsalted. Butter is a water-in-oil emulsion in which the moisture is evenly distributed in tiny droplets. Butter that contains too much moisture is more prone to spoilage due to its high level of free water, which supports bacterial growth and spoilage.

Butter can be made by churning either cream or whole milk; the latter must be sour to make it easy for fat globules to agglomerate into butter granules. Traditional butter making in Africa is based on churning of sour milk. The churning takes place in various traditional vessels including gourds and clay pots, and it takes about one hour for butter to form. In Ethiopia, where butter plays a very important role in the diet of the local people, ILRI has developed an internal agitator for the traditional clay pot churn which reduces the churning time to less than 45 minutes and results in higher fat recovery from the sour milk.



Figure 5.8: Traditional butter churning in a gourd (A), clay pot (B) and ILRI's improved clay pot with internal agitator (C)

Other simple churns may be made from aluminium milk cans (Figure 5.9 A, 5.9 C and 5.9 D) or wood (Figure 5.9 B).

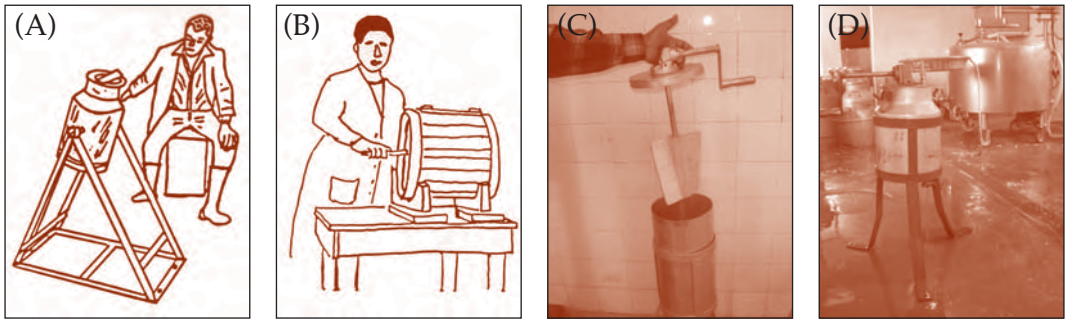


Figure 5.9: Simple hand driven butter churns (Adapted from Kurwijila, 2005)

5.4 Ghee

Ghee is anhydrous butterfat made by evaporating moisture from either cream or butter. Ghee contains 99.9 per cent butterfat. It is used traditionally for cooking and medicinal purposes. Making ghee from butter requires less energy compared to using cream. The butter is heated over a low fire until all the moisture has evaporated and the temperature rises to 120–125°C. The preparation of ghee is ready when frothing stops and the non-fat solids turn slightly brown. Care must be taken to avoid overheating the ghee. Good quality ghee should have a straw yellow colour, not brown. It should be stored in opaque or dark coloured glass jars to avoid rancidity due to fat oxidation.

5.5 Fermented milk

Naturally fermented milk is the most common milk food in Africa. It is traditionally produced by letting milk ferment spontaneously in vessels such as clay pots, gourds, vessels made out of wood, animal skin as well as woven straw (Figure 5.10). The spontaneous fermentation causes milk to coagulate when the pH reaches 4.6 and below. The naturally fermented milk provides a preserved product with a shelf life of a few days to two weeks, depending on the processing procedures used. Special procedures for fermentation of *ititu* in Ethiopia, *nono* in West Africa, *rob* in Sudan or *kule naoto* of the Maasai in East Africa give milk a shelf life of three weeks or more.



Figure 5.10: Some traditional milk fermentation vessels from Ethiopia

Traditional milk processing technology results in products that have a special appeal to the communities that produce them. However, members of these communities who migrate to urban centres often have no access to the traditional products or, because of changing taste preferences, consume more of the industrially processed dairy products. Industrially processed fermented milks include cultured buttermilk made by use of mesophilic starter cultures, and yoghurt which is made using a thermophilic lactic starter culture of two lactic acid bacteria species: *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. These consumers provide a niche market for industrially fermented milk and a fraction of this market can be captured by small-scale processors. This, however, would require that fermented milk products be processed hygienically in order to guarantee safety and consistent quality.

Hygienic processing of fermented milk

Hygienic production of cultured milk products whether sour milk or yoghurt follows seven basic steps:

- Selection and propagation of a suitable starter culture
- Reception and quality control of the raw milk

- Heat treatment to render the milk suitable for growth of lactic acid bacteria
- Inoculation with starter culture
- Incubation at suitable temperature and time duration to achieve the desired acidity
- Cooling to arrest further acidification where appropriate
- Packaging and storage

Important points to note during the processing of fermented milk products are described below.

Milk supply

Whole, partially skimmed, skimmed and reconstituted milk have all been successfully used to manufacture various fermented milk products. In certain countries where the level of production is significant, sheep, goat and buffalo milk are widely used to make fermented milk. The milk must be free from off-flavours and inhibitory factors. Antibiotic residues will completely inhibit or cause slow growth of lactic cultures, even at low concentrations. Residues of quarternary ammonium compound-based dairy sanitisers (QACs) inhibit the activity of lactic cultures, resulting in slow fermentation. Rancid milk containing caprylic, capric and lauric acids and inhibitory substances produced by bacteria may also inhibit culture growth. Hence, raw milk meant for production of cultured milk must be of high quality.

Heat treatment

Milk used for the manufacture of cultured dairy products is often heated at 82–85°C for 30 minutes or 88–95°C for 3 to 5 minutes. Such heating achieves at least 80 per cent denaturation of whey proteins, which contributes to the viscosity and consistency of the coagulum; destroys contaminant bacteria and some natural inhibitors present in milk; liberates sulfhydryl groups from the whey proteins (especially β-lactoglobulin) and expels oxygen. These changes



Figure 5.11: Heating milk in water bath using improved firewood stove (Source: Kurwijila, 2005)

make the milk a better medium for growth of lactic acid starter culture bacteria. Heating to temperatures below 82°C and above 88°C for 30 minutes causes a weak coagulum and whey separation, and may inhibit starter culture growth due to formation of toxic volatile sulphides.

The resulting interactions between casein particles and whey proteins increase the water binding capacity of the casein thereby minimising the tendency of wheying-off during subsequent handling of the product. The resulting acid coagulum or curd can be stirred to form a smooth, viscous product with optimal viscosity and whey retention.

Starter culture inoculation and incubation

The starter culture inoculation rate for buttermilk/sour milk is usually recommended by the supplier as it depends on the type, incubation temperature and activity of the lactic acid bacteria strains used in the manufacture of the commercial culture. However, the inoculation rate commonly ranges between 0.5 and 2 per cent. The rate of the starter culture addition should be adjusted such that the desired acidity is attained within 12–16 hours at an incubation temperature of 21–22°C. It is important that the incubation temperature is maintained within 1–2°C of this range. If higher temperatures are used, the acid-producing bacteria *(Lactococcus lactis* and *Lactococcus cremoris*) tend to outgrow the aroma producers (*Leuconostoc* spp. and *L. lactis* ssp. *lactis* biovar. *diacetylactis*). With carefully selected starter cultures, incubation temperatures of up to 24–27°C have been used with good results under conditions where the control of temperature was not technically or economically feasible. Ambient temperatures in most parts of Africa render the production of mesophilic lactic cultured milk practical and cost-effective.

Breaking the coagulum

Many processors of buttermilk-like products (sour milk, *maziwa lala, nono, ititu, amasi* etc.) break the coagulum when the pH reaches 4.5–4.7. Titratable acidity can be used to determine the optimum time to break the coagulum. Fermented milk of good aroma and consistency is achieved when the titratable acidity is in the range of 0.7–0.9 per cent. For a good product viscosity and rich aroma, it is best to cool

the coagulum to less than 10°C for several hours before stirring it. Cooling the coagulum is essential for yoghurt manufacture.

Enhancing the viscosity and consistency of cultured milk

The acidification of milk, and subsequent coagulation of casein at pH 4.6 (isoelectric point), increases the viscosity of the milk. Viscosity is an important quality characteristic of foods such as cultured milk because:

- It influences the body and mouth feel of the product
- Products with high viscosity are more difficult to heat, stir, pump or mix than those of lower viscosity
- Foods of very low viscosities may be associated with low nutritive value

Various techniques are used to optimise the viscosity of cultured milk products. These include:

Increasing the content of total solids

Generally, the viscosity of fluids increases with increasing amounts of dissolved solids. Levels of 9–10 per cent and 12–16 per cent solids are considered optimum for viscosity of cultured milk and yoghurt, respectively. Where whole milk is used, 12–14 per cent total solids (TS) may be sufficient to guarantee a product of the desired viscosity and consistency. However, where skimmed or partially skimmed milk is used as the raw material, it is often necessary to increase the TS content. This may be done by adding skim milk powder to increase the SNF content or evaporating the base mix or raw milk to the desired per cent TS level. For example, during manufacture of yoghurt, the desired TS content of 16 per cent is achieved by evaporating 10–25 per cent of the raw milk or adding 1–3 per cent skim milk powder.

Adequate heat treatment

Proper heating of milk intended for manufacture of cultured dairy products is important for optimum viscosity. Heating at 82–85°C for 30 minutes or 88–90°C for 3–5 minutes gives best results. It is important to note that inadequate heat treatment of milk often causes weak-bodied, curdy-textured milk products which easily whey off. Heating the milk can easily be done in an improved firewood cooker (Figure 5.12).



Figure 5.12: Removing milk can after heating (Source: Kurwijila, 2005)

Incubation temperature and time

Mesophilic lactic cultured milk products such as buttermilk, sour milk and sour cream are incubated at 21–22°C for 14–16 hours. At curdling point (0.6 per cent lactic acid), casein is at its minimum state of hydration. As the acidity increases to 0.75–0.8 per cent lactic acid, hydration and whey retention capacity increase and the stability of the product is improved. Longer incubation time causes acidity and viscosity to increase, but with adverse effect on the whey retention capacity of the curd. For the best results on viscosity, it is better to vary the rate of inoculation rather than the temperature or time of incubation.

Yoghurt starter cultures have their optimum symbiotic growth at 40–43°C, whereby a ratio of bacilli to cocci of 1:1 to 1:1.2 and 1:10 is maintained in natural and fruit yoghurt, respectively. Incubation time of 3–4 hours is sufficient to attain the desired pH and acidity at this temperature. Higher incubation temperatures of 45–46°C lead to rapid acid production in the last stages of the fermentation, leading to a very firm, compact coagulum with high tendency for severe whey separation and weak viscosity upon stirring and fruit addition.

In the case of yoghurt, within certain limits, lower incubation temperatures and consequently longer incubation periods tend to favour higher product viscosity. It is possible to produce yoghurt of excellent flavour and viscosity by using a low inoculation rate of 1 per cent starter culture and incubating at 30°C for 16 hours. This is called the "long-set" method and it has been used by some commercial dairies with considerable success.

Use of slime-producing starter cultures

There are some commercially-produced high viscosity starter cultures that produce a slimy, viscous coagulum in yoghurt. Slime-producing strains of *Lactobacillus delbrueckii* ssp. *bulgaricus* are mixed in a 1:1 ratio with *Streptococcus salivarius* subsp. *thermophilus* to produce these special cultures. In mesophilic starter cultures, slime production may be enhanced by incubation at low temperature (19–20°C) whereby certain strains of *Lactococcus cremoris* may form long chains.

5.6 Cultured buttermilk (sour milk)

Different types of mesophilic starter cultures are used in the manufacture of fermented milks in various countries. Buttermilk is a by-product of butter that has been processed from sour cream. The cream is first heated to 70–75°C for 20–30 minutes then fermented by inoculation with starter cultures containing *Lactococcus lactis* and *Lactococcus cremoris* for production of lactic acid, and *Leuconostoc* spp. or *Lactococcus lactis* subsp. *lactis* biovar. *diacetylactis* for production of flavour and aroma compounds (mainly diacetyl). Buttermilk from churning of sour cream contains 0.5–0.6 per cent butterfat and lecithin from the fat globule membrane which gives a characteristic "buttermilk" taste. Buttermilk made in this way has a limited shelf-life and a high tendency for wheying off. It must therefore be consumed quickly. In African societies, buttermilk is made by churning spontaneously fermented sour milk in various vessels. The buttermilk is consumed along with other foods or converted to cottage cheese (e.g. *ayib* in Ethiopia).

In many countries, industrial manufacture of buttermilk or sour milk is made by direct fermentation of skimmed or partially skimmed milk with appropriate mesophilic starter cultures. In East Africa it is known as *maziwa lala* or *mala,* or simply *maziwa mgando* (coagulated milk) or *mtindi* (sour milk).

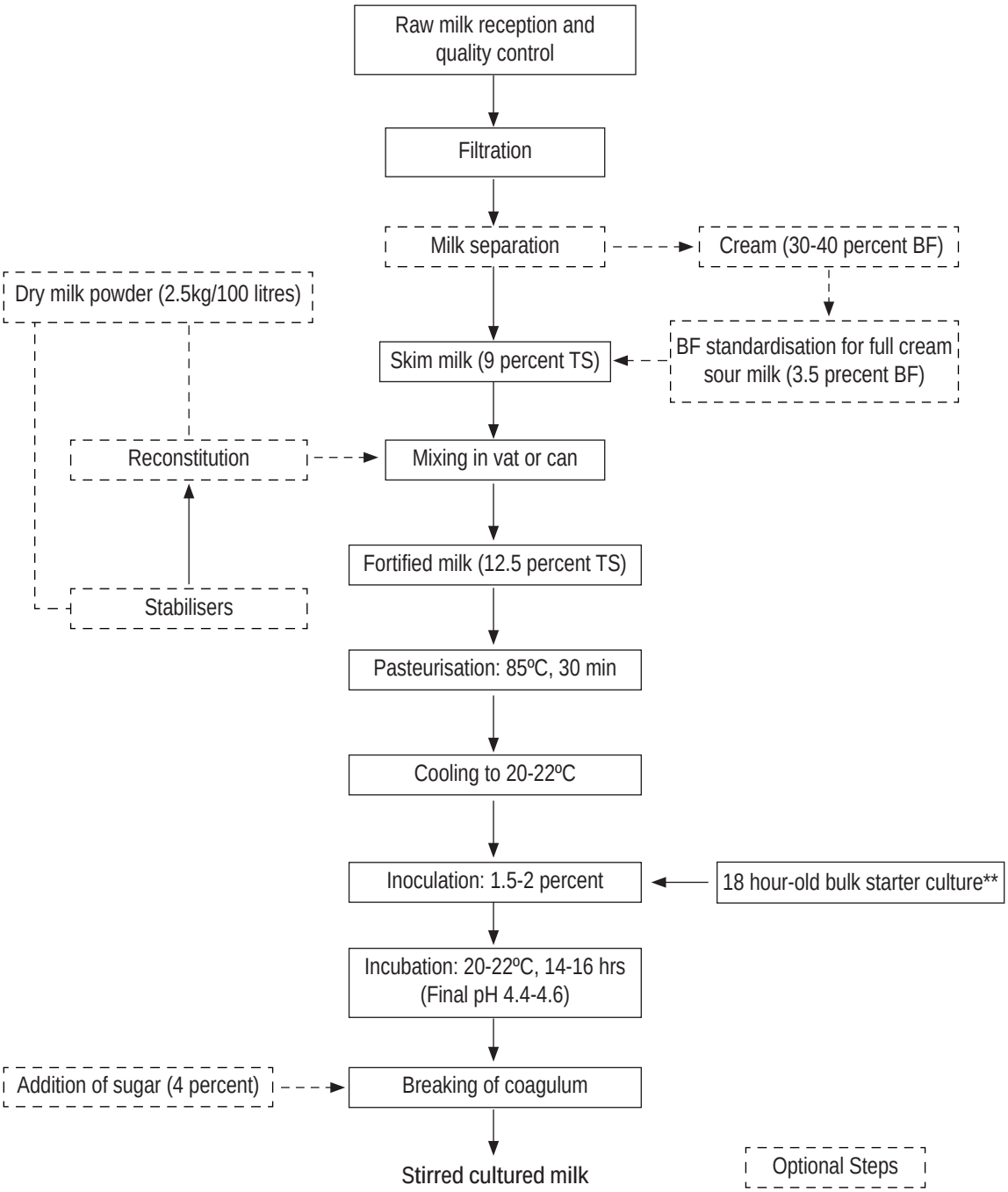
Commercial production of sour milk is on the increase for various reasons:

- Compared to fresh milk, it has a better keeping quality of 3–5 days at ambient temperature
- Unlike yoghurt, its preparation does not require the use of incubators



- Cooling of the curd after fermentation is not as critical as it is in production of yoghurt because acid production by mesophilic starter cultures is self-limiting at about 0.8–1.2 per cent lactic acid, whereas the activity of the yoghurt starter bacteria must be arrested by cooling the product.
- The flavour of sour milk is similar to that of traditional fermented milk products in sub-Saharan Africa and therefore it is readily acceptable by African consumers.

The procedure for production of cultured buttermilk/sour milk by use of mesophilic starter culture is shown in Figure 5.14. The product can be served out of bulk containers in large catering units such as schools, restaurants and hotels. For retail sales in kiosks, milk bars, parlours, shops and supermarkets, the product can be packaged in plastic sachets.



***In the absence of a commercial starter culture, a portion of previously fermented milk may be used as a starter. Fermented milk used in this way should have been processed under very clean conditions and should have an acceptable flavour. Fermentation of such milk should be "clean" and show no signs of excessive gas formation and whey separation.*

Figure 5.14: Process flow chart for production of fermented milk (Adapted from Kurwijila, 2005)

5.7 Yoghurt

Yoghurt has its origins in Bulgaria hence it is sometimes referred to as "Bulgarian milk". It may be produced from different types of milk, including skimmed or partially skimmed milk from cows, goats, sheep or water buffaloes. According to Codex Alimentarius standards, yoghurt must contain viable and abundant living cells of thermophilic lactic acid bacteria, *Streptococcus salivarius* subsp. *thermophilus* (SST) and *Lactobacillus delbrueckii* subsp. *bulgaricus* (LDB). The preparation of yoghurt follows the seven basic steps described for cultured buttermilk/sour milk (refer to section on *Hygienic processing of fermented milk*). The description below gives specific requirements for production of good quality yoghurt.

5.7.1 Starter culture

The yoghurt starter bacteria have a special symbiotic relationship. They each have different growth requirements; SST has optimum growth at 40°C while LDB grows optimally at 40–45°C. Hence the commonly used incubation temperature of 42°C is a compromise for both species in order to achieve a near 1:1 ratio of bacilli to cocci in the final product. Commercial yoghurt starter cultures are available as frozen liquid cultures or in freeze-dried (lyophilised) powder form. Nowadays, both frozen and lyophilised cultures come in form of Direct Vat Set (DVS) for direct vat inoculation. DVS cultures come in sachets for direct application in vats of 500 litres and above, and may therefore not be suitable for small-scale processors. Freeze-dried starter cultures for conventional, traditional propagation are still available but care has to be taken to ensure the highest level of hygiene and avoid contamination and loss of starter activity.

The correct incubation temperature must be adhered to in order to maximise the symbiotic growth of the starter bacteria. SST grows faster than LDB and produces mainly lactic acid, some formic acid and carbon dioxide. It is responsible for the initial acidification of the milk to pH 5.0. The formic acid and carbon dioxide produced stimulate the growth of LDB, whose proteolytic activity produces some peptides and amino acids required for optimal growth of SST. LDB, being more acid-tolerant, carries forward the fermentation to pH 4.0, or lower if the coagulum is not cooled. LDB also produces acetaldehyde, the main flavour compound in yoghurt.

The preparation of yoghurt starter culture by propagation from stock culture follows the scheme outlined below.

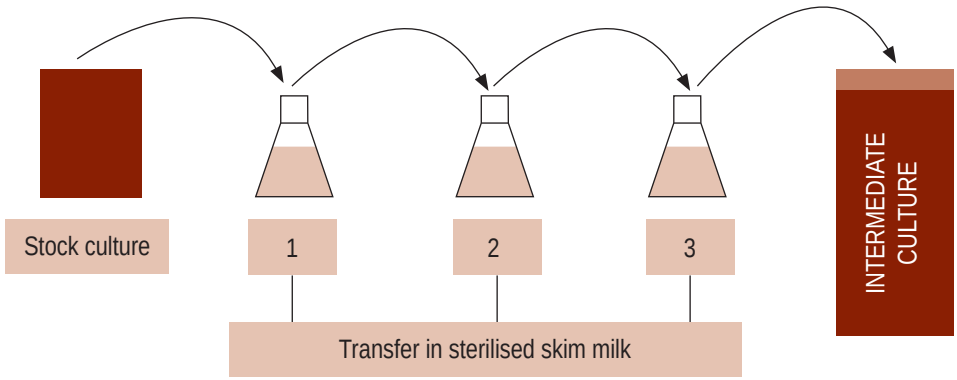


Figure 5.15: Traditional starter culture propagation (Adapted from Kurwijila, 2005)

5.7.2 Yoghurt manufacture

Milk

Milk for the production of yoghurt must be fresh and of good bacteriological quality. It must be free from residues of antibiotics and dairy sanitisers. Colostrum and mastitic milk must not be used for yoghurt manufacture as they will not withstand the heating required to render milk suitable for processing. Equipment used must be clean and free from bacteriophages.

There are two main types of yoghurt: set and stirred yoghurt. Set yoghurt is incubated in the retail container, usually a plastic or glass cup. It is the preferred method for production of natural yoghurt and yoghurt with fruit and/or nuts. The consumer breaks the curd with a spoon at the time of consumption. Stirred yoghurt, on the other hand, is incubated in bulk vats after which the curd is stirred, mixed with sugar and flavours, then packaged in retail cups and sealed. Figure 5.16 shows the flow chart for the manufacture of the two types of yoghurt.

After reception and quality control, the milk is heated to 40–45°C, clarified and separated into cream and skim milk. The milk may be standardised to the desired

fat content to make either full-fat yoghurt (3.2–3.5 per cent fat), low fat yoghurt (1.5–2.0 per cent fat) or skim milk may be used to make skim milk yoghurt (less than 0.5 per cent fat). Standardisation of total solids content may also be done by adding 1.3–2.5 per cent skim milk powder or evaporating 10–25 per cent of the water in the milk, which is equivalent to adding 1.5–3 per cent skim milk powder. This is done in order to increase the viscosity of the yoghurt, improve its water binding capacity and reduce whey separation (syneresis) in the sour coagulum.

Additives such as stabilisers or sugar may be added at this point, depending on the type of stabiliser and type of yoghurt. Normally yoghurt of high viscosity can be produced from full-fat milk without adding stabilisers. In some countries additives are not permitted. Stabilisers may be required for low-fat drinking yoghurt which has a total solids content of not more than 11 per cent.

Heat treatment

As for production of cultured milk, heat treatment of milk at 82–85°C for 30 minutes or 90–95°C for 3–5 minutes is critical for the quality of yoghurt with respect to its viscosity, consistency and prevention of wheying off. Milk is then cooled to the incubation temperature of 42°C.

Starter culture inoculation and incubation

A previously prepared bulk starter culture is added at the rate of 2–3 per cent and the inoculated milk is then incubated at 42°C. Depending on the activity of the starter culture, development of acidity to the required pH of 4.5–4.6 should be attained within 3–4 hours.



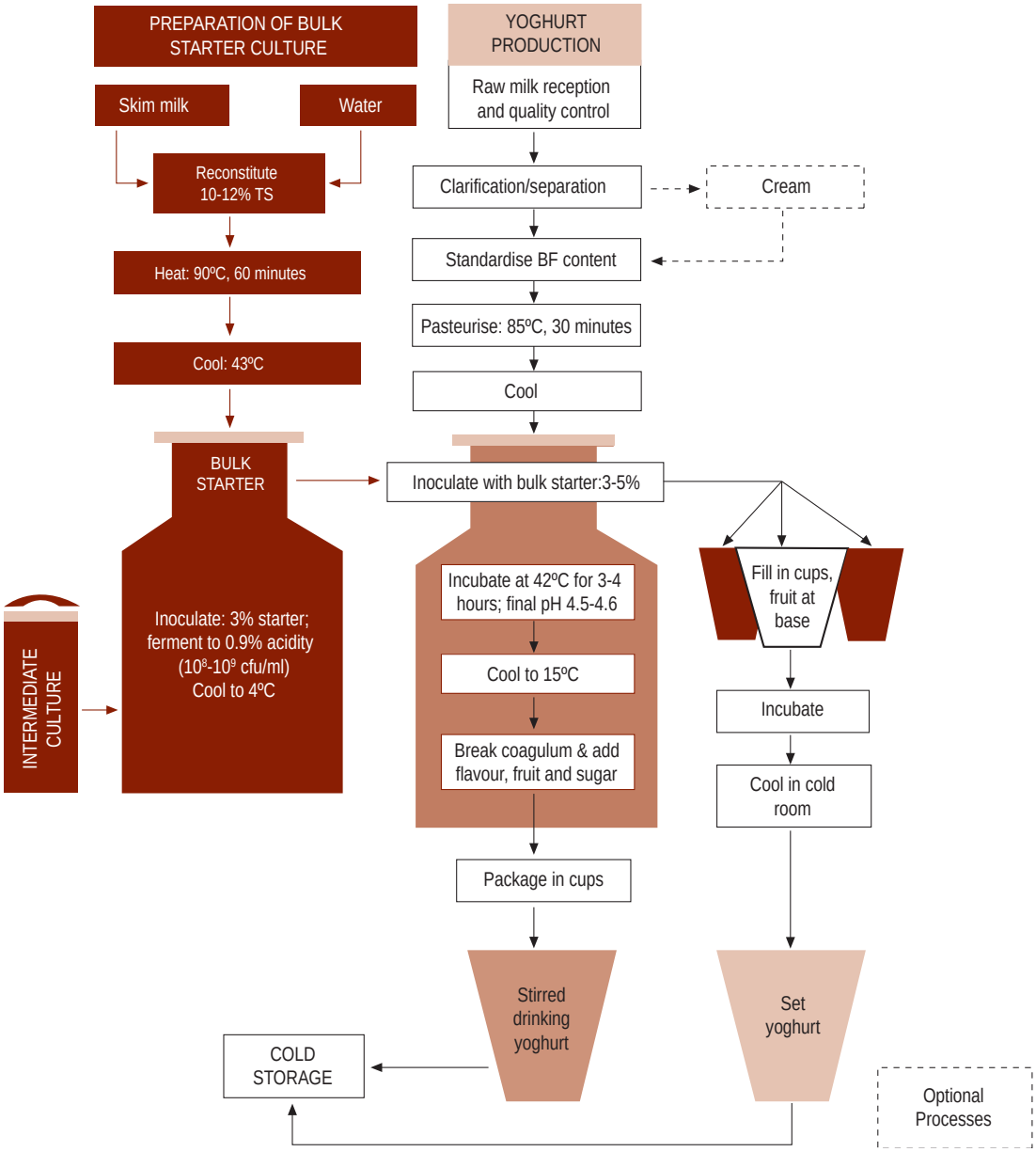


Figure 5.16: Process flow chart for production of yoghurt (Source: Kurwijila, 2005)

5.7.3 Practical exercise

You have been provided with 60 litres of whole milk in two 30-litre aluminium cans. The butterfat content of the milk is 4.0 per cent or more. You are required to make equal batches of sour milk and yoghurt containing 3.5 per cent butterfat. You will have to separate cream from a portion of the milk and use the resulting skim milk to standardise the remaining whole milk to 3.5 per cent butterfat. Thereafter you will make cultured sour milk and yoghurt following the procedure outlined in this module.

Objectives

The objectives of this exercise are to enable participants:

- Learn the technique of milk standardisation
- Acquire skills to help them process fermented milk products hygienically

Materials and equipment

- Milk separator
- Two cans of milk (each containing 30 litres)
- Water bath heater (using gas) or improved charcoal/firewood stove
- Cooling water trough
- Mesophilic starter culture
- Yoghurt starter culture
- Plastic sachets or cups (for packaging the finished product)

Standardisation

Follow guidelines in Section 5.2.4 on "Milk standardisation".



Procedure

As in Figure 5.14 (sour milk) and Figure 5.16 (yoghurt).

Evaluation

Measure the final pH and acidity of the products and assess their taste. Add flavours as desired. A detailed description of these tests is given in Appendix 1.



Figure 5.17: Basic appropriate technology for processing cultured milk

5.8 Some African traditional and exotic cheeses

5.8.1 Introduction

Cheese is one of the most highly concentrated and nutritious dairy products. It is commonly made in Europe and North America but it is not widely consumed in Africa. Exceptions include *wagashie*, a soft cheese made by Fulani pastoralists in West Africa, and *ayib*, an Ethiopian soft cheese. In the rest of Africa, cheese is a relatively new food product consumed mainly in urban centres by foreign visitors and Western-educated African elites.

Even though the quantity of cheese produced in sub-Saharan Africa is low, FAO data show that imports are on the increase. In 2003, Africa produced 755,000 metric tonnes of cheese and imported 72,190 metric tonnes worth US$ 189 million. Exports increased from 13,833 metric tonnes worth US$ 27 million in 2000 to 28,502 metric tonnes worth US$ 64 million in 2003. Given the high value of cheese and its increasing importance in African diets, its future prospects may be likened to the introduction

of maize and cassava into Africa several hundred years ago by European explorers; today these crops form the backbone of staple foods on the continent. Hence, the importance of the cheese-making technology in shaping the future diets of African people cannot be ignored.

5.8.2 Definition

The Codex Alimentarius Commission defines cheese as: *"the ripened or unripened soft or semi-hard, hard and extra-hard product, which may be coated and in which the whey protein/casein ratio does not exceed that of milk, obtained by coagulating whole or partly skimmed milk and/or products obtained from milk, through the action of rennet or other suitable coagulating agents, and by partially draining the whey resulting from such coagulation"*. While unripened cheese is ready for consumption immediately after manufacture, ripened cheese undergoes maturation under specific temperature and humidity storage conditions for such time that will result in biochemical and physical changes that are characteristic of the specific cheese.

5.8.3 Types of cheese

Cheese is obtained principally through coagulation of casein by milk-coagulating enzymes, acid precipitation, or a combination of the two. Cheese-making was discovered more than 2000 years ago by Middle East nomads who found out that milk they carried in containers made out of calf stomachs coagulated after sometime and the curd so formed was edible. Since then, cheese making has grown from an art into a science. Due to variations in climates and local tastes, there are today more than 400 varieties of cheeses made throughout the world. They all contain protein, fat, water, vitamins and salt in varying amounts depending on the type of cheese.

Cheese may be classified based on the moisture content of the fat-free solids, the fat content of the dry matter or type of ripening.

Classification based on moisture content of the fat-free solids:

- Soft (69 per cent or more)
- Semi-hard (57–69 per cent)
- Hard (49–56 per cent)

- Extra hard (less than 49 per cent).

Classification based on fat content of the dry matter:

- High fat (60 per cent or more)
- Full fat (45–59 per cent)
- Medium fat (25–44 per cent)
- Partially skimmed (10–24 per cent)
- Skimmed (less than 10 per cent)

Classification based on type of ripening:

- ripened
- mould-ripened
- unripened / fresh
- in-brine
- whey cheese

Mould-ripened cheese is ripened by the growth of selected mould species in the interior and / or surface of the cheese. Whey cheese is the solid or semi-solid product obtained by concentrating whey, with or without the addition of milk, cream or other raw material of milk origin, followed by moulding of the product.

5.8.4 *Principles of cheese making and general manufacturing procedure*

Although there are hundreds of cheese varieties, the basic steps involved in cheese making are common to all, with only minor variations. These steps are explained in detail below:

Preparation of the cheese milk

The basic characteristics of any cheese–such as butterfat content and the fat-to-casein ratio–are determined by the ratio of fat to protein in the milk. These can be manipulated to suit a certain type of cheese by adjusting or standardising the fat content of the milk. After standardisation, the milk may or may not be pasteurised depending on the cheese type. Pasteurisation of the cheese milk influences the curd characteristics and the biochemical processes that take place during ripening due to the action of native enzymes and those produced by microbial flora present in milk. The milk should be of high quality, free from antibiotics, disinfectants and pesticide residues which can inhibit starter culture growth. All equipment which comes into contact with milk should be sanitised to prevent build-up of bacteriophages. If cheese is to be made from previously cooled milk, thermisation to 60°C without holding may help correct the balance of soluble calcium ions. In larger factories, bactofugation may be undertaken at this stage to reduce the number of spore-forming bacteria which could cause problems of late blowing of matured cheese.

Calcium chloride may be added to cheese milk at the rate of 5-20 grams per 100 litres to improve the firmness of the curd and prevent "shattering" or very fine curds which get lost in the whey. If bactofugation is not carried out, saltpetre (sodium or potassium nitrate) may be added at the rate of 20 grams per 100 litres of milk to prevent early and late blowing of the cheese caused by gas-producing coliforms and anaerobic spore-forming bacteria (e.g. *Clostridium tyrobutyricum*), respectively.

Ripening of the cheese milk

In rennet cheeses, the starter culture is added 30 to 40 minutes before renneting in order to lower the pH of the milk to 6.45–6.5, which is optimal for rennet activity. The type of starter culture influences the biochemical and physical changes that occur during the preparation and maturation of specific cheese varieties. Lactic starter cultures produce flavour compounds from break down of lactose, proteins and butterfat. Some produce carbon dioxide from heterolactic fermentation of lactose contributing to formation of holes (eyes) in the cheese. *Propionibacterium shermanii* is responsible for production of large quantities of carbon dioxide in Emmentaler, a type of Swiss cheese. Table 5.2 shows some lactic cultures used in the manufacture of various cheeses.



Renneting

Addition of an appropriate coagulant is an important step in cheese making. Calf rennet is the traditional choice of coagulant but rennet preparations containing various proportions calf rennin (chymosin) and bovine pepsin are common nowadays. Rennet substitutes are also available commercially; these include microbial rennet from microorganisms such as *Mucor mihei*, and plant coagulants (vegetable rennet).

Table 5.2: Starter cultures used in various cheeses

	Cottage cheese	Camembert, Brie	Cheddar	Emmentaler	Gouda	Mozzarella	Parmesan
L. lactis subsp. *lactis*							
L. lactis subsp. *cremoris*	✓	✓	✓		✓		
L. lactis subsp. *lactis* biovar. *diacetylactis*					✓		
Leuc. mesenteroides subsp. *mesenteroides*					✓		
S. salivarius subsp. *thermophilus*				✓		✓	✓
Lactobacillus spp.				✓		✓	✓
Propionibacterium shermanii				✓			
Penicillium spp.		✓					

Cutting the curd

After the curd has formed and become firm, it is cut into cubes of various sizes depending on the type of cheese. Very fine cubes facilitate loss of whey from the cheese curds, resulting in hard to very hard cheeses. Semi-hard and soft cheeses require curds of larger cube size that retain more moisture in the cheese.

Working and cooking the curd

Once the coagulum has been cut into cubes of appropriate size, the temperature of the whey is slowly raised from 32–35°C to the final cooking temperature of 38–45°C depending on the desired hardness of the cheese. Higher cooking temperatures favour more moisture loss and are therefore applied for hard to very hard cheeses. Soft cheeses and semi-hard cheeses are cooked at 38°C. During this phase the cheese curd is constantly stirred while large curds are stabbed or cut with cheese knives to

the correct size. Cooking of the curd is ready when the curds become firm and do not stick together when pressed by hand.

Forming and pressing

Once the curd has been cooked to the desired consistency, the whey is drained off and the curds placed in round, square, cylindrical or rectangular moulds and pressed for at least one hour before turning and pressing again for 12 to 16 hours. This allows further drainage of whey from the curd. The pressure applied must be appropriate to the size and type of cheese. In order not to trap moisture in the space between curd particles, the first pressing should be light and the weight applied not more than ten times the weight of the cheese.

Salting

After the cheese is removed from the cheese press it may either be dry salted or immersed in a concentrated brine solution for 6–22 hours depending on the size of the cheese.

Curing and ripening

After salting, the cheese is left to dry and the surface may be treated by waxing or applying plastic coatings. These prevent mould infection and minimise moisture loss from the surface of the cheese. Rindless cheese may be hermetically sealed in impermeable plastics. Ripening at specific temperatures and humidity then follows for four weeks to six months or more, depending on the type of cheese.

5.8.5 Processing of specific cheese varieties

Cottage cheese

Cottage cheese is the simplest cheese to make. It is usually made by acidifying skim milk through lactic acid fermentation by selected lactic starter cultures. These include homolactic fermenters *Lactococcus lactis* and *Lactococcus lactis* ssp. *cremoris* as well as some heterofermentative species such as *Leuconostoc mesenteroides* ssp. *mesenteroides* (formerly *Leuconostoc dextranicum*).

There are two basic methods of making cottage cheese: long and short set methods.

"Long set" acid curd method

- After pasteurising and cooling the skimmed milk, a mixed starter culture is added at the rate of 1 to 2 per cent without adding a coagulating agent.
- After inoculation, the cheese milk is incubated at 22–24°C for 14–16 hours during which period coagulation takes place.
- The curd is then cut into 7–15 mm cubes, depending on whether a fine or coarse textured curd is desired.
- The curd is cooked by raising the temperature slowly to 38°C in 30 to 35 minutes while stirring gently for one minute every 5 minutes.
- The temperature is then raised to 45–50°C in 10–15 minutes and held for another 15–20 minutes with occasional gentle stirring to avoid shattering and matting of the curd. The cooking process promotes lactic acid fermentation and enhances expulsion of whey, causing the curds to become firm.
- The firm curd is scooped and poured into a sieve lined with cheesecloth. The whey is allowed to drain into a suitable receptacle such as a bucket or simply drained off if there is no further use for it. Whey may be used for animal feed, as a cooking aid or for preparing whey cheese.

"Short set" sweet curd method

- The short set method follows the same steps as the long set method except that it involves the use of starter culture and addition of small quantities of rennet. Rennet makes it possible for the curd to form within three to five hours. The curd is also thicker and more resistant to shattering.
- After pasteurisation, the milk is cooled to 30–32°C then inoculated with starter culture at the rate of 2–3 per cent, and rennet at the rate of 0.1–0.2 grams per 100 litres. The milk is left undisturbed at this temperature for three to five hours, until coagulation is complete.



- Once a firm curd has formed, it is cut into small pieces of about 1.5 cm. Firmness of the curd is tested by cutting it with a knife and lifting to see if a neat slice can be lifted from the milk.
- Cooking of the curd is done by raising the temperature from 30–32°C to 45–48°C in 30–40 minutes.
- The curd is left at the final cooking temperature for 15–20 minutes until it is firm enough.
- Draining and cooling the curd proceeds as described for the long set method.

Creamed cottage cheese may be prepared from both acid and sweet curd cottage cheese by adding sufficient cream to increase the butterfat content to four per cent. The mixture is homogenised to make a creamy spread.

Queso blanco cheese

Queso blanco (Spanish for "white cheese") is a Latin American creamy white cheese made from pasteurised cows' milk. It is a semi-hard cheese made by precipitating milk proteins through direct acidification with lemon juice or organic acids. The following procedure is used in making *queso blanco*.

Raw milk

Only fresh milk of good quality should be used. After quality checks and clarification, the milk is standardised to 3 per cent butterfat, which gives the optimum ratio of casein to fat.

Acidulant

Fresh lemon juice is prepared at the rate of three per cent of the milk to be coagulated. The lemon juice is diluted with an equal amount of clean, potable water. Acetic, citric or lactic acids as well as cider vinegar may be used as acidulants.

Precipitation of milk proteins

The milk is heated to 82°C in a double jacketed vat or double boiler. Lemon juice is then added to the milk while stirring. The milk will curdle immediately the pH

is lowered to about 4.6. The coagulated milk is stirred slowly for a further three minutes to ensure thorough mixing of the lemon juice with the milk, which is then left undisturbed for 15 minutes.

Filtration, salting and pressing

To drain the whey, the curdled milk is filtered through a cheese cloth placed in a colander or over a suitable container. To enhance the shelf-life and taste of the fresh cheese, salt is added at the rate of three percent of the weight of the cheese curd. The salted curd is placed in rectangular or round moulds and pressed with at least 10–15 times its weight for 12 hours. The cheese blocks are removed from the press and may be cut into suitable sizes ready for selling and consumption. Because it is a fresh cheese, it needs to be refrigerated. About eight litres of milk of three per cent butterfat will yield one kilogram of *queso blanco*. The cheese may be eaten directly or sliced and eaten on bread. It may also be fried without losing its shape. This type of cheese is easily adaptable to small-scale milk processing. *Queso blanco* should have a smooth, firm body free from pinholes, and a closed, well-cooked texture that gives clean slices or chunks which do not break easily.

Brine cheese

Brine cheese is a type of white cheese made and preserved in concentrated salt solution for two weeks to several months or longer. It evolved in warm Mediterranean countries and the Middle East, and is popular in Egypt and the Sudan. Types of brine cheese include *feta, halloumi, domiati* and *gibna byda.* They were originally made from sheep milk (hence the white colour) but nowadays are increasingly being made from goat and cow milk. Cow milk gives the cheese a yellowish colour which may not be desirable, depending on the market. Brine cheese is particularly suitable for long storage in warm climates where high temperatures increase the cost of manufacture of ripened cheese, which must be cured under refrigerated conditions. The procedures for producing each of these cheeses are described below.

Domiati

Domiati is an Egyptian, white brine pickled cheese. It is also known as *gibbneh beda* or *damiati.* It is made in the form of round cheeses about 12 cm wide and three to

four cm thick. Buffalo milk containing six to seven per cent butterfat gives the best quality *domiati* cheese but cow and buffalo milk may also be used.

Milk

Traditionally, *domiati* was made from raw milk or milk which had been heated to 65°C for 15 minutes or less. Increasingly, *domiati* is now made from milk pasteurised at 60 to 80°C for 15–60 seconds. Salt is added directly to the milk at the rate of 6–14 per cent. In the case of pasteurised milk, calcium chloride may be added at the rate of 2–4 grams per 100 kg of milk.

Coagulation and whey drainage

After pasteurisation, the milk is cooled to 35–45°C and calf rennet added at a rate that will result in slow coagulation within two to three hours without addition of starter cultures. The curd is scooped into wooden moulds of suitable size (12 x 11 cm or 50 x 50 cm). The moulds are placed over a porous straw mat or cheesecloth and drained for two to three days without pressing. Large blocks may be pressed with weights equal to their own weight. Once the curd block is firm enough it is cut into cubes measuring 8 x 8 cm and placed into large tins in layers. The tins are filled with concentrated brine solution of 14–15 per cent salt and sealed or welded to make them air-tight. The air tight tins are stored for six to nine months at 20–25°C or under refrigeration until when required. The widespread production of this and other types of cheeses have made Egypt the leading cheese producer in Africa.

Gibna byda

Gibna byda is similar to *domiati* and is popular in neighbouring Sudan. It is made from cow milk to which 7–10 per cent salt has been added. Coagulation is achieved by use of calf rennet at rates that bring about firm coagulation of the milk within four to six hours. After coagulation, the curd is scooped into rectangular moulds lined with cheese cloth and left to drain overnight under its own weight or pressed for two hours with 15 times the weight of the curd. The curd is then cut into 10 x 10 cm cubes and placed in a tin which is then filled with whey and sealed. Large quantities of *gibna byda* are made in the Sudan, Africa's second largest producer of cheese.

Halloumi

Halloumi, a firm pickled cheese, has its origin in Cyprus where it is made mainly from sheep milk. It is also made in other countries in the Mediterranean region such as Syria. Apart from sheep or goat milk, cow milk may also be used to make *halloumi* cheese. After pasteurisation at 63°C for 30 minutes, the milk is cooled to 32°C and rennet added at a rate enough to cause coagulation within 40–50 minutes. The curd is then cut with a cheese knife into cubes measuring 3–4 cm and stirred gently while raising the temperature to 40–42°C in about 30 minutes. After stirring for another 20 minutes, the curd is left to settle for the whey to separate. The whey is drained and heated to 80–90°C. The curd is scooped into wooden moulds lined with cheese cloth and then pressed for three to four hours after which it is removed from the press and cut into 10 x 2 cm pieces. The curd pieces are placed in the hot whey and left undisturbed until they start floating on the whey. The floating curds are scooped onto a draining table and left to cool for 20–30 minutes. The pieces of cheese are sprinkled with three to five per cent salt and placed in containers which are then filled with saturated brine (15 per cent salt). The cheese lasts for several months in sealed containers. About 9 litres of milk will yield one kg of *halloumi* cheese. *Halloumi* may be eaten plain or fried with onions and eaten as a snack.

Feta

Feta can be made without starter culture. Milk is standardised to three per cent butterfat, heated to 32°C and allowed to ripen naturally for one hour before adding enough rennet to cause coagulation within 40–50 minutes. The resulting curd is then cut into 2–3 cm cubes and left to stand for 15 minutes after which it is slowly stirred to allow the whey to separate. After the curd has settled, the whey is decanted. The curd and some whey are transferred to a wooden cheese mould lined with cheese cloth. A lid is placed on the mould which is inverted at half-hourly intervals. The curd is left overnight in the mould after which it is cut into blocks of suitable size and sprinkled with salt. The salted blocks are then placed in a 15 per cent brine solution which enables the cheese to keep for several months without spoilage. About 9 litres of milk will yield one kg of *feta* cheese.

Wagashie

This a traditional cheese made in many countries of West Africa, including Benin, Ghana and Burkina Faso. It is known also as *wara* in Nigeria. The cheese is produced by fermenting milk with a coagulant extracted from young leaves and stems of the Sodom apple plant, *Calotropis procera* (Figure 5.18). Coagulation takes place at higher temperatures (55–60°C) and is complete when the curd attains a temperature of 70–80°C. An extract from about 30 grams of leaf material is enough to coagulate one litre of milk. The coagulant is prepared by adding about 150 grams of finely chopped fresh leaves and stalks into 100 ml of potable warm water.

Fresh morning milk is used as the raw material for production of *wagashie*. The milk is heated to 50–60°C and the Sodom apple coagulant is then added at the rate of 30 grams of fresh material per litre of milk. The milk is heated further with intermittent stirring. Coagulation occurs when the milk temperature is about 74–84°C. Once there is clear separation of curds from the whey, the curds are poured into perforated calabash moulds placed over a container to collect the whey. The curd is left in the moulds for the whey to drain after which the cheese is removed and placed in a container of cool water.



Figure 5.18: Sodom apple plant

To give it colour, the cheese may be dipped in a hot solution of red sorghum stems and leaves. *Wagashie* is normally consumed fresh or fried and eaten as a snack. Traditionally the cheese is boiled repeatedly to prolong its shelf-life to three to four days after which it tends to become fibrous. Studies to prolong the shelf-life of *wagashie* have shown that placing the cheese in 10 per cent brine solution for 12 hours significantly improves shelf-life from three to 10 days.

Gouda (ripened cheese)

Among the European ripened cheeses, baby Gouda is the most widely manufactured by rural small-scale processors in East Africa. Most are female farmers who process between 50 and 200 litres of milk a day. Small-scale cheese processing is an appropriate way of adding value and preserving milk in highland areas where the

relatively cool climate obviates the need for air conditioning. The major prerequisite is that the processor must be close to market outlets, which in most African countries comprise major city hotels and supermarkets.

The manufacture of most ripened cheese varieties follows the basic principles outlined in section 5.8.4. Once the basics of cheese making have been mastered, it is easy to adapt them to other cheese varieties by adhering closely to the respective recipes.



Figure 5.19: Cheese making with simple equipment in Arusha, Tanzania



Figure 5.20: A simple water jacketed cheese vat

Materials required

A cheese vat of appropriate size, preferably one with a water jacket around it

Rennet

Mesophilic starter culture

Cheese curd cutting knife

Round cheese moulds

Cheese press

Brine tank

Curing room with wooden shelves

Procedure

Use fresh milk for manufacture of ripened cheese. Gouda cheese can be made from full-fat milk or standardised milk of 3 to 3.5 per cent butterfat, depending on the desired fat content in the final cheese (full-fat of half-fat cheese).

1. Pasteurise the cheese milk at 63°C for 30 minutes.
2. Cool the cheese milk to 32°C.
3. Add mesophilic cheese starter culture at the rate of 2–3 per cent.
4. Leave the milk to ripen for 30 minutes; the acidity should drop to 6.45–6.5.
5. Add rennet at a rate that will cause coagulation within 30–40 minutes.
6. Test the firmness of the curd to see if it is strong enough to be cut without shattering.
7. Cut the curd into 5 mm cubes.
8. Stir the curd gently while cutting (stabbing) larger pieces.
9. Remove some whey and heat it to 60–70°C.
10. Raise the temperature slowly from 32°C by adding hot whey directly to the cheese curd or adding hot water in the jacket so that temperature of the curd reaches 38–40°C in 30–40 minutes. This called cooking the curd.
11. Check the firmness of the curd. It should feel firm but not rubbery.
12. Scoop the curd and press it for one hour in the round mould designed to hold 1–2 kg of cheese.
13. Turn the cheese (Figure 5.21) and press again for 12 hours with ten times its weight.

14. Remove the cheese from the press and place it in a brine tank containing 15 per cent salt for 12 hours.
15. Remove the cheese from the brine solution and store it in a ripening room (Figure 5.22).
16. Every other day, clean the surface of the cheese with a clean cloth immersed in brine solution to remove mould. The cheese surface may be waxed by the third day. Ensure that the surface of the cheese is clean and dry before waxing.

Ripen the cheese for at least four weeks. The longer the ripening period, the richer the flavour of the cheese and the mellower and softer it becomes. Baby Gouda cheese that has been ripened for four weeks has a mild, pleasant flavour.



Figure 5.21: Turning mini Gouda cheese

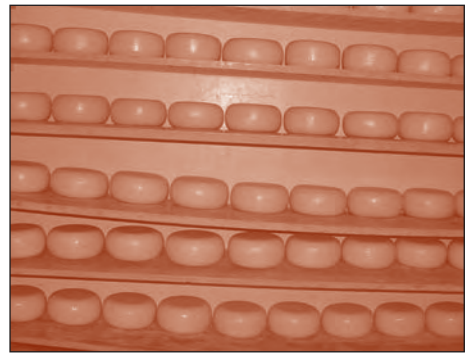


Figure 5.22: Ripening baby Gouda cheese at Kyaka, Bukoba, Tanzania (Photo by L R Kurwijila)

CHAPTER

6

Record keeping and business management by small-scale farmer groups, milk traders and processors

6.1 Importance of record keeping

Records enable small-scale operators of milk businesses to keep track of all transactions carried out by the business. These include the amount of milk supplied, payments made, suppliers, creditors, debtors, and so on. Dairy farmers' records help them keep track of the costs of inputs used in milk production (animal feeds, drugs, veterinary services, labour, milk cans, etc.) and how much income they are getting from the sales of milk, heifers, cull cows, bulls, etc. Milk producer groups need to keep records of their members, how much milk is supplied by individual members, raw milk quality, quantities of milk sold and how much is wasted, and payments received for milk sold to processors, transporters or traders.

Similarly, milk traders or transporters who buy milk from individual farmers for sale to processors or consumers need accurate records of the quantities of milk traded and associated costs. Milk processing plants need to keep accurate records of the quantity and quality of each consignment of milk received from suppliers. Additionally, specific records have to be kept for each product and process in the processing hall. Such records are required not only for business transactions but also for quality assurance, food safety and traceability. Indeed, modern quality assurance systems such as HACCP (Hazard Analysis Critical Control Point) require keeping of detailed records at each step of food processing.

This chapter gives an overview of important records and sound business practices for milk producer groups, traders, transporters and processors. Some guidelines for



ensuring good product quality and a profitable business are also discussed.

6.2 Records for milk producer groups

The keeping of good records is particularly important to dairy farmer groups, associations and co-operatives. Records of milk supplies and payment enable the management to know who owes money to the group and how much should be paid to individual members. Also, with good records in place, handing over of assets and liabilities of the group is made easier in the event of a change of leadership. Some of the basic records that milk producer groups should keep are discussed below. In some cases, similar records may be kept by the individual members.

6.2.1 Milk supply records

The milk delivery card is a basic record of the quantity of milk supplied by individual farmers. It may also indicate details of the raw milk quality and the grade of milk delivered. A sample milk delivery card is shown in Table 6.1. The milk delivery card is retained by the farmer.

Table 6.1: Sample milk delivery card

Name of farmers' group: Modern Village Milk Producers Group							
Name of member: Mrs Mary Paul							
Membership no. 0023							
Year: 2005					Month: Jan.		
Date:			Milk delivered (kg)				
	a.m.	p.m.	Total (kg)	% fat	Resazurin test	Grade	Farmer's signature
1.							
2.							
3.							
……..							
31							
Total							

Note: "Milk delivered" refers to milk that was accepted on the basis of passing the alcohol test and having a lactometer reading between 26 and 32.

The data on the milk delivery card is then entered into a consolidated record of milk deliveries for the entire group (Table 6.2).

Table 6.2: Sample consolidated daily milk supply record

Name of farmers' group: Modern Village Milk Producers Group				
Date:				
Amount delivered (kg)				
Name of supplier	a.m.	p.m.	Total (kg)	Farmer's signature
1.				
2.				
3.				
etc				
Total				

Farmers are then paid for their milk deliveries on the basis of a milk supplier payment record (Table 6.3). Payments may be made weekly, fortnightly or monthly.

Table 6.3: Sample milk supplier payment record

Name of farmers' group: Modern Village Milk Producers Group					
Milk payment record					
Month: ..... Year:					
Farmer no.	Milk delivered (kg)	Av. grade	Price/kg	Total payment	Signature
001					
002					
003					
....					
Total					

Apart from the above milk supply records, farmer groups may also keep records of the amounts of milk sold and payments received.



6.2.2 Financial and non-financial records

Some important financial records that the producer group should keep are cash books, ledgers, delivery books, invoices and receipts. A sample cash and bank book is shown in Table 6.4. Other important (non-financial) records include the members' register, minute book and constitution.

Table 6.4: Example of a simple cash and bank book

Date	Particulars	Ref.	Cash in	Cash out	Balance	Debts	Particulars	Ref.	Bank in	Bank out	Balance

6.3 Records for milk traders and transporters

Milk traders buy, transport and sell milk to consumers or wholesalers. On the other hand, milk transporters may be specialised agents who transport milk on behalf of either producers or processors for a fee, based on the quantity of milk transported. Unlike milk traders who own the milk between the source and destination, milk transporters do not assume ownership of the milk but only a contractual responsibility to deliver the milk in good condition to its destination.

Depending on the type of contract, both the trader and the transporter may bear part or all of the risk of loss due to spoilage of milk in transit. Studies in informal milk markets in Kenya, Tanzania, and Ghana have shown that small-scale traders often bear the full risk of loss of milk in transit as there are no written contracts with the farmer/supplier. Besides milk supply and delivery records, traders and transporters need to keep a record of the costs of maintaining the transport vehicles and replacing milk cans and testing equipment. Here are some basic records that should be maintained by milk traders and transporters.

6.3.1 Milk supply records

Daily milk supply records should indicate the name of supplier, volume of milk supplied, date and time the milk was supplied and the price paid for the milk. Apart from these basic records, it is in the interest of both transporters and suppliers to



assess and record the quality of the raw milk transported. Records of these quality tests are useful in deciding who bears the cost of milk spoilage in cases where milk is found to be spoilt at the time of delivery to the point of sale or processing factory. The following measurements and basic quality tests may be carried out and the results recorded by the transporter:

- Temperature of milk
- Density of the milk
- Organoleptic test
- Alcohol test

6.3.2 Milk sales/delivery record

Upon delivery of milk to the point of sale or processing factory the following should be recorded:

- Name of customer
- Date and time of delivery
- Price of milk delivered
- Temperature of milk
- Density of milk
- Organoleptic quality
- Results of alcohol test

6.3.3 Financial and non-financial records

Financial records for milk traders and transporters include cash books, ledgers, delivery books, invoices and receipts. Other important (non-financial) records include agreements and/or contracts between the milk transporter and farmer groups, individual farmers or milk processors.



6.4 Records for small-scale milk processors

A milk processing unit consists of several departments–milk reception, processing, storage and distribution, and finance/administration–each of which needs to keep specific records.

6.4.1 Milk reception

Upon reception, the quality of the milk is assessed by carrying out one or more "platform tests" (organoleptic, clot-on-boiling and alcohol tests). To ascertain the bacteriological quality of the milk, the "10 minutes resazurin test" may be carried out. Records of the results of these milk quality tests should be kept. Milk of acceptable quality is received and weighed. An accurate record of the weight of milk received from each supplier must be maintained in order to determine payments to be made. This data is entered into a daily milk intake record sheet/card (Table 6.5).

Table 6.5: Sample daily milk intake record

MILKYCOW DAIRY LTD									
DAILY MILK INTAKE RECORD									
Month: ..... Year:									TOTAL
Date	1	2	3	4	5	6	7	8 etc	
Supplier No.									
001									
002									
003 etc.									
Total									

In addition to the record of milk delivered by individual suppliers, a consolidated record of milk delivered per day by all suppliers (Table 6.6) should be kept. The contents of butterfat and total solids are also recorded as these parameters are useful in controlling mass balance and product yield in the factory.

Table 6.6: Sample consolidated daily milk intake record

Date	Milk received (kg)	Percent fat	% Butterfat	% TS
1				
2				
3				
etc				
Total				

The weight of milk received is also indicated on the milk payments record (Table 6.7), which should be kept by both the supplier and the milk processor.

Table 6.7: Sample milk payments record

THE MILKYCOW DAIRY LTD					
Year:		Month:		Period: .....(..... Days)	
Supplier no.	Milk delivered (kg)	Milk grade	Price/kg	Payment	Signature
001					
002.					
003					
etc					
Total					

6.4.2 *Milk processing hall records*

Milk processing should be carried out such that the quantity of milk received corresponds to the volume of products that will be produced, depending on the yield factors for the products. For example if a factory is making cheese only and nine litres of milk are needed to produce one kg of cheese, then for every 100 litres of milk received, about 11 kg cheese will be produced after allowing for reasonable wastage of milk solids. If half of that milk is used to make butter from cream and the skim milk is used in standardising the cheese milk, then a mass balance or milk utilisation record (Table 6.8) will show how much cheese and butter should be expected.

Table 6.8: Sample milk utilisation record

THE MILKYCOW DAIRY LTD								
Year: 200.....			Month:			Period: .....(..... Days)		
Date	Milk received (kg)	Volume Separated (kg)	Cream obtained (kg)	% BF in cream	Skim milk (kg)	Standardised cheese milk (kg)	Cheese produced (kg)	Butter produced(kg)
1								
2								
3								
etc								
Total								

Apart from the production and milk utilisation records, other records include temperature charts and other process parameters (pH, acidity) for various products as well as laboratory quality parameter records. Specific products such as butter or ice cream have special parameters, such as over-run, which need to be known for both quality control and control of mass balance in the dairy.

6.4.3 Methods of keeping records

Records can be kept by filling in special forms or recording in specially designed ledger books. The advantage of using forms is that records are entered in a predetermined and systematic way, but the main drawback is that they are easily lost or misplaced. Ledger books are handy in the office but not easy to carry around. Whatever method one chooses to use, records need to be entered daily. From forms, ledger books and other books of accounts, the data may be entered into a computer for further analysis and reporting

6.4.4 Financial records

Properly kept financial records can be used to determine the cash in-flows and out-flows, draw up the balance sheet and make a profit-and-loss statement.

Cash flow records

These are records of receipts (in-flows from sales) and payments (out-flows made on purchases from suppliers). In order to ensure that the business is not interrupted by the lack of cash, in-flows should always be higher than out-flows. A simple cash flow record is shown in Table 6.9.

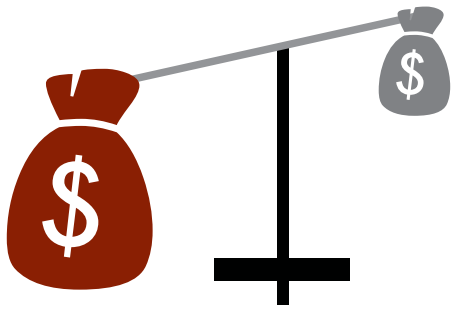


Table 6.9: Example of a cash flow table

In-flows (Revenue)				Out-flows (Expenditure)			
Item	Quantity (litres)	Price/litre	Value	Item	Quantity (litres)	Price	Value
1. Milk sales	100	0.30	30.00	1. Milk purchases	101	0.20	20.2
				2. Fuel	10	0.5	5.0
				3. Labour	1	1.0	1.0
Total	100		30				26.2

Balance sheet

The balance sheet compares the assets and liabilities of the business (Table 6.10). The value of **assets** (physical and financial) has to balance with the value of **liabilities** plus **shareholders equity.**

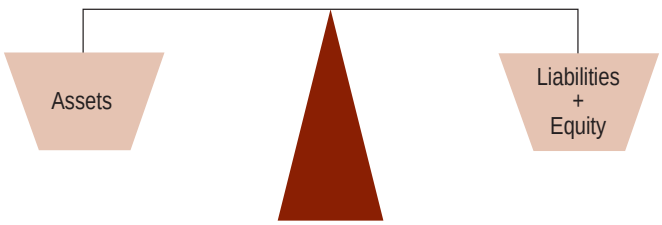


Table 6.10: Example of a balance sheet for a milk transport business

	2004	2003
Assets		
Current assets		
Cash and equivalents	2,000	1,500
Accounts receivable	1,150	900
Inventory	800	600
Total current assets	3,950	3,000
Buildings (Real estate)	25,000	20,000
Equipment (depreciated value)		
Pick-up car	4,000	5,000
Milk cans	1,500	2,000
Goodwill (Image, Reputation)	800	500
Total assets	35,250	30,500
Liabilities		
Current liabilities		
Accounts payable	1,500	2,000
Short term debt	200	300
Total current liabilities	1,700	2,300
Long term debt	100	150
Other liabilities	100	50
Total liabilities	1,900	2,500
Shareholders equity	33,350	28,000

Profit-and-loss statement

The profit-and-loss statement is a financial tool that indicates the amount of profit or loss the business made during a specified financial period. It is a financial statement showing the costs, revenue and profit (or loss) of the business in a given period of time. The record is prepared from information recorded on the balance sheet.

Taking the example of the balance sheet for a milk transport business (Table 6.10), the profit-and-loss statement is worked out taking into account how much it cost to transport the milk to the market and how much revenue was collected from sale of the milk over the accounting year, which is normally any 12-month period.

6.5 Starting a milk trade, transport or small-scale processing business

Before starting any business, one needs to develop a business plan. Some key aspects to consider during this process are outlined here:

6.5.1 Market research

This essential first step involves establishing key market information about the business you want to start. These and other questions need to be addressed in assessing the market:

- Where will the milk be sourced from?
- How much milk is likely to be available?
- Are there seasonal fluctuations and by how much?
- What is the price for the milk?
- Does the price vary depending on season or location?
- Where are the markets?
- Are there wholesalers, retailers or other major buyers such as processors, schools, and hospitals?
- What are consumer preferences and how much are they prepared to pay?

6.5.2 Marketing plan

This focuses on:

- "The 4 Ps of marketing", namely, product, price, place, promotion. Which products will be sold, and at what price? Where will the products be sold and how will they be promoted?

- Who are your competitors?
- What is the size of the market?
- What is your targeted market share?

6.5.3 Production plan

- What inputs will you need (raw materials, machinery and transport equipment)?
- What are the labour requirements (skilled, unskilled)?
- Will you build or hire the premises?

6.5.4 Organisational plan

- What form of ownership and organisation will the business have?
- Who will manage the business?
- What qualifications will you look for in a manager?
- How many employees will you need and what will they do?
- How will you keep records?
- What licenses and permits will you require?
- What regulations will affect your business?

6.5.5 Financial plan

This is heart of the business plan. You have to address the following questions:

- What is the estimated business income for the first year?
- What will it cost you to open the business?
- What will the monthly cash flow be during the first year?
- What sales volume will you need in order to make a profit in the first year?
- What is the break-even level of production?

- What is the capital value of the equipment?
- What are the total start-up capital needs?
- Who are the potential sources of funding?

For example, if you decide to enter into the business of collecting and transporting milk it is important to observe the following:

- Carry out a survey in the intended area of milk collection to establish potential milk supply, number of farmers, amount of marketable milk available, number of competitors (if any) and how much milk they collect, expected volume of milk you are likely to get and what the seasonal variations are likely to be, and expected prices for milk during the flush and dry season.
- Map out the shortest milk collection route that will give the highest amount of milk per kilometre travelled.
- Determine the frequency of milk collection and capacity of the transport vessels and vehicles you will need.
- Work out the capital investments you will need.
- Prepare a business plan detailing the expected cash flow over a period of one year and forecasts for the next three years.
- Determine whether the business will be profitable and whether you can repay your capital investments within a reasonable period of time compared to alternative investments in the area.
- Determine the legal set-up of your business, including arrangements for obtaining the necessary certification and licences. These include:
  - milk transport dealership licence
  - public health certificate
  - driving licence
  - road licence for motor vehicle, plus insurance cover
  - other local levies and permits



- Familiarise yourself with the code of hygiene for milk transporters and traders if available, otherwise follow the guidelines outlined in this module.

Once you have established the above you will need to:

- Negotiate with farmers on the price of the milk and mode of payment
- Agree on minimum quality standards of the milk
- Draw up a contract and supply arrangements with your suppliers for specific periods of time as mutually agreed.

NOTE: Most small-scale milk producers are poor farmers whose livelihoods depend largely on the income they get from selling milk. Hence it is important to support them by running your business efficiently. Here are some practices to adhere to:

- Test raw milk to ensure that you collect only milk of good quality.
- Collect and transport milk efficiently so as to minimise losses.
- Accurately weigh the quantities of milk supplied and sold.
- Pay your suppliers promptly.
- Maintain high standards of personal hygiene and ensure cleanliness of milk vessels and the transport vehicle.
- Always follow the legal requirements of running your business.
- Run your business ethically and never default on paying farmers.

CHAPTER

7

Basic code of hygienic practices, regulations and standards for the dairy industry

7.1 Importance of regulations and standards

The dairy industry plays an important role in the socio-economy of most countries in sub-Saharan Africa. Millions of smallholder farmers depend on milk production for their household income and nutrition. The dairy industry contributes significantly to employment creation; it is estimated that four to five jobs are created for every 100 litres of milk sold. This includes thousands of on-farm employees, small-scale traders, transporters, processors as well as those involved in wholesale and retail businesses of the dairy industry inputs and outputs. For this reason, governments strive to create conditions that are conducive to the growth and competitiveness of their domestic dairy industries. The requisite conditions include laying down procedures, codes of practice, regulations and standards that ensure quality and fair play in the dairy industry.

Quality assurance in the dairy industry is important in safeguarding public health from the risks of milk-borne diseases. It is also important that dairy industry stakeholders understand the regulatory environment in which they have to operate. Without going into details of the specific regulations, standards and codes of practice in the respective countries, the basic elements are common and are described in this chapter.



7.1.1 Definitions

Code of practice

This is a set of moral principles or rules of behaviour that are generally accepted by society or a social group–a strict code of conduct. It can also be viewed as a system of laws or written rules that state how people in an institution or a country should behave. A good example is the penal code.

Code of hygienic practice

This is a set of guidelines for the safe handling of foods. When applied to milk, the code of hygienic practice addresses all hygienic and safety requirements from farm-level production, transportation, processing and distribution. It covers specifications for premises, equipment and personnel involved in the production, marketing, processing and distribution of food. The code of hygienic practices may be part of regulations put in force by national legislations governing the dairy industry or a national standard under the Standards Act. The code of hygienic practices in most countries is structured according to that published by the FAO Codex Alimentarius commission. The code may also take the form of Good Farming Practices for the farm level, Good Manufacturing Practices for the food processing industry, and so on. However, the over-riding objective is to facilitate the production of **safe and nutritious food products.**

Standards

Standards are specifications for processes, procedures and product composition. They are normally put together by national bureaus of standards for specific products and processes. Dairy industry standards thus form guidelines for the production of safe, wholesome and nutritious dairy products. Some standards are voluntary while others are compulsory. Food and Dairy Products Standards are mostly compulsory.

Regulations

Regulations are sets of guidelines or directives issued by competent authorities under a law governing the dairy industry. They are usually enforceable under law

and include marketing orders, fees, taxes, etc.

Law

A law is a principal legislation governing a specific industry. There are several laws which govern the operation of the dairy industry, but the main ones that address the issue of quality are the Food and Drugs (Pharmaceuticals) Act, Dairy industry Act, Public Health Act and others governing specific aspects of the industry such as labour laws.

Procedures

Procedures are sets of practices specified by authorities or regulations. They may involve application for permits, licences and filling tax returns as part of the conditions for conducting a specific business.

Policy

Policy refers to a general set of authoritative statements by a government, which is reflected in the laws, regulations, procedures, standards and directives governing the conduct of operations or practices within an industry.

Aim of policy, standards and regulations

The aim of policy, standards and codes of practice is to:

- Create harmony
- Standardise product quality and processes
- Promote fair play
- Meet safety requirements
- Avoid hazards and liabilities
- Enhance market access

Enforcement agencies

These are public agencies that ensure that laid down regulations and standards are complied with so as to maintain order and fair play in the industry.

Regulators

Regulators are public agents who control an industry by means of enforcing laws or/and regulations of the industry. Dairy industry regulators are compliance officers related to regulation, standards, and law and order.

Medium and small-scale enterprises (MSEs)

These refer to medium and small-scale operators in the dairy industry including milk traders, milk transporters, market-oriented producers and small-scale processors.

7.1.2 Basic elements of good hygienic practices

Establishments that produce and handle milk are known as dairies. A dairy must fulfil hygienic conditions with regard to the following:

Buildings: Dairy buildings must be located on well-drained sites away from other animal and human activities. They must be constructed using durable and cleanable material with adequate provision for ventilation, lighting, sanitation and waste disposal.

Water: There must be adequate potable water.

Personnel: All persons involved in handling of milk and dairy products must be well-trained in milk hygiene and should not handle milk if suffering from infectious diseases.

Quality control laboratory: There has to be a well-equipped laboratory for quality control.

7.1.3 Practical exercise

1. List the principal laws that govern the operation of the dairy industry in your country.

Legislation	For who (Farmers, traders, transporters, etc.)	Requirements	Implications for MSEs
Food and Drug Act, (19…)	Milk traders		
Dairy Industry Act, (20..)			

2. List the regulations under the principal food laws governing the operation of the dairy industry, showing how they influence the performance of MSEs in your country.

Regulation	For who (Farmers, traders, transporters, etc.)	Requirements	Implications for MSEs
Cow housing	Farmers		

3. For each of the products below, indicate the national standard for composition and microbiological quality and their implications for MSEs.

Product	Parameter	Minimum standard	Implications for MSEs
Raw milk	Density		
	Per cent butterfat		
	Per cent SNF		
	Total Plate Count		
	Coliform count		
	Faecal coliforms		
	Containers		
	Transport		
	Preservation		
Pasteurised milk			
Sour milk			
Butter			
Cheese			

References

IDF Doc. No. 9002. Handbook on milk collection in warm developing countries. International Dairy Federation, Brussels, Belgium.

ILCA Manual No.4 Rural dairy technology. Experiences from Ethiopia.

Kurwijila, L.R. 2005. Dairy Technology in Africa. Unpublished draft book manuscript.

Mala manual: A guide for establishing and operating small-scale enterprises for the production of cultured milk by Technoserve.

Marth, E. H. 1978. Standard methods for the examination of dairy products. 14th ed. American Public Health Association.

O'Connor, C. 1995. Rural dairy technology: ILRI Training Manual No. 1. ILRI (International Livestock Research Institute), Addis Ababa, Ethiopia. 123 pp.

Shepherd, A. W. 1993. A guide to marketing costs and how to calculate them. FAO Marketing and Rural Finance Service, Agricultural Service Division, FAO, Rome, Italy.

Shepherd, A. W. 2003. Market research for agro-processors. FAO marketing extension guide no. 3. FAO, Rome, Italy.

Appendix 1
Additional milk quality control tests

1. Milk sampling

Accurate sampling is the first pre-requisite for a fair and just quality control system. Liquid milk in cans and bulk tanks should be thoroughly mixed to disperse the milk fat before sampling. Plungers and dippers are used in sampling milk from milk cans.

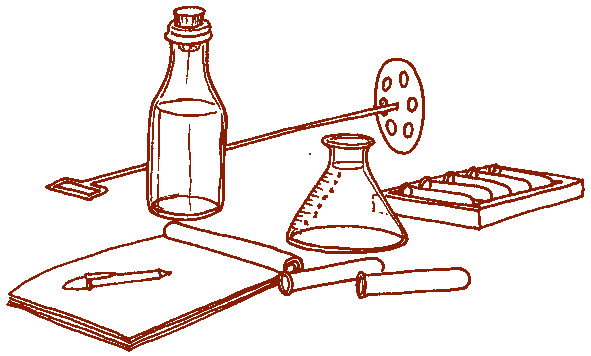


Figure 1: Some equipment used for taking milk samples

1.1 Sampling for bacteriological testing

Sampling milk for bacteriological tests requires a lot of care. Dippers should be sterilised in an autoclave or pressure cooker for 15 minutes at 120°C before use in order not to contaminate the sample. On-the-spot sterilisation with 70% alcohol swab and flaming, or scalding in hot steam may also be used.

1.2 Preservation of milk samples

If a milk sample cannot be analysed immediately after sampling, it must be cooled quickly to near freezing point and maintained at that temperature until it is transported to the laboratory. If samples are to be taken in the field (e.g. at a milk cooling centre) they can be preserved in ice boxes with ice packs. Milk samples that have been cooled in a refrigerator or ice-box must first be warmed in a 40°C water bath then cooled to 20°C and mixed well before analysis.

Milk samples for butterfat testing may be preserved with potassium dichromate–one tablet or 0.5 ml of a 4% solution in a 0.25 litre sample bottle is adequate. Other chemical preservatives include 0.08% sodium azide and 0.02% Bronopol (2-bromo-2-nitro-1, 3-propanediol).

1.3 Labelling and record keeping

Samples must be clearly labelled with the name or code number of farmer, date of sampling and the place where the sample was collected. This information should also be included in standard data sheets. Records must be kept neat and stored in a dry place. Milk producers should be present at the time of sampling and the records should be availed to them if they so require.

2. Titratable acidity

Acidity in raw milk is developed by the action of bacteria that ferment lactose to lactic acid. Fresh milk also contains 'natural acidity' of 0.16–0.17 per cent lactic acid due to natural ability to resist pH changes. Levels of acidity greater than 0.17 per cent lactic acid indicate developed acidity due bacterial activity that results in production of lactic acid. When determining the titratable acidity, any acid present is neutralised by titrating with 0.1N sodium hydroxide and the volume of titre is then used to calculate the level of acidity as per cent lactic acid.



Figure 2: Apparatus for determining titratable acidity

Apparatus

Porcelain dish, conical flask

10 ml pipette, graduated

1 ml pipette

50 ml burette

Phenolphthalein indicator (0.5% in 50% alcohol)

0.1N sodium hydroxide

Procedure

1. Pipette 9 ml of milk into the porcelain dish/conical flask.
2. Add 1 ml of phenolphthalein to the sample and mix.
3. Titrate slowly with 0.1N sodium hydroxide under continuous mixing until a faint pink colour appears.
4. Record the volume of sodium hydroxide used in the titration.
5. Calculate the titratable acidity as per cent lactic acid by dividing the volume of sodium hydroxide by 10.

3. Resazurin test

The resazurin test is most widely used for determining the hygiene level and potential keeping quality of raw milk in terms of the number of bacteria it contains. Resazurin is a dye indicator that is blue when oxidised and white under reduced oxygen levels. The dye is added to the milk and judgement is made based on the colour produced after a specified incubation time. High numbers of bacteria in the milk will remove the dissolved oxygen much faster, so the dye becomes more discoloured than if the milk had only a few bacteria.

This test can be carried out as a 10-minute, one-hour or three-hour test. The 10-minute resazurin test is useful as a rapid screening test that can be done at the milk reception platform. The one-hour and three-hour tests are usually carried out in the laboratory and provide more accurate information about the milk quality, but after a fairly long time.



Apparatus and reagents

Resazurin tablets

Distilled water

Test tubes with 10 ml mark

1 ml pipette or dispenser for resazurin solution

Thermostatically-controlled water bath

Lovibond comparator with 4/9 resazurin disc

Procedure

1. To prepare the resazurin solution, add one resazurin tablet to 50 ml of distilled water. Do not expose the resazurin solution to sunlight or store it for more than eight hours because it will lose strength.
2. With a sanitised dipper, transfer 10 ml of milk into a sterile test tube.
3. Add one ml of resazurin solution to the milk sample, stopper the test tube and gently mix the dye into the milk.
4. Mark the test tube and place it in a 37°C water bath for 10 minutes.
5. Remove the test tube from the water bath and put it in a Lovibond comparator with a resazurin disc.
6. Compare the colour of the sample with a test tube containing 10 ml of milk but without the dye (blank).

Interpretation of results (10-minute resazurin test)

Resazurin disc number	Colour	Grade of milk	Action
6	Blue	Excellent	Accept
5	Light blue	Very good	Accept
4	Purple	Good	Accept
3	Purple-pink	Fair	Separate
2	Light pink	Poor	Separate
1	Pink	Bad	Reject
0	White	Very bad	Reject

4. Gerber butterfat test

In many countries, the fat content of milk and cream is the most important factor in determining the price paid for milk supplied by farmers. Also, in order to calculate the correct amount of feed ration for high-yielding dairy cows, it is important to know the butterfat content and yield of the milk produced. Furthermore, the butterfat content in the milk of individual animals must be known in many breeding programmes. The butterfat test is also done on milk and milk products in order to make accurate adjustments of the butterfat percentage in standardised milk and milk products.

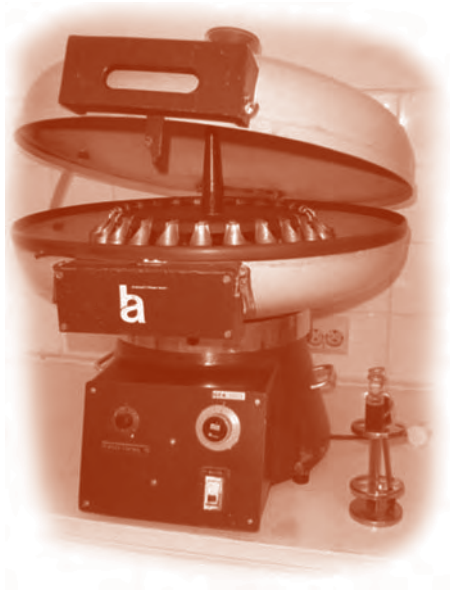


Figure 3: Equipment used in butterfat determination by Gerber method

Apparatus and reagents

Gerber butyrometers (0–6% or 0–8% butterfat)

Rubber stoppers for butyrometers

11 ml pipettes for milk

10 ml pipettes or dispensers for acid

10 ml pipettes or dispensers for amyl alcohol

Butyrometer stands

Centrifuge

Gerber water bath

Gerber sulphuric acid (specific gravity 1.82)

Amyl alcohol

Procedure

1. Add 10 ml sulphuric acid to a butyrometer followed by 10.7 or 11 ml of well-mixed milk and then 1 ml of amyl alcohol. Avoid wetting the neck of the butyrometer.
2. Close the butyrometer with a rubber stopper and shake it carefully until the curd dissolves and no white particles can be seen.
3. Place the butyrometer in a 65°C water bath until the set is ready for centrifuging.
4. Place the butyrometers in the centrifuge with the stem (scale) pointing towards the centre and spin for five minutes at 1100 rpm.
5. When the centrifuge has come to a complete stop, remove the butyrometers and return them to the water bath at 65°C for 3 minutes, ensuring the water level is high enough to heat the fat column. When transferring the butyrometers from the centrifuge to the water bath, hold them with the stem end pointing up.
6. Read the butterfat percentage off the scale. If necessary, adjust the fat column by regulating the position of the stopper.

7. Empty the highly corrosive contents of the butyrometers into a special container. Wash the butyrometers in warm water and dry them before the next use.

Appearance of the test

- The colour of the fat column should be straw yellow, and free from specks and sediments.
- The ends of the fat column should be clearly defined.
- The fat should be within the graduated scale.
- The acid just below the fat column should be perfectly clear.

Problems in test results

A fat column that is too lightly coloured or curdy may be due to:

- Low temperature of milk and/or acid
- Low concentration of acid
- Insufficient acid
- Inadequate mixing of the milk and acid

A darkened fat column containing black specks at the base may be due to:

- Excessively high temperature of the milk-acid mixture
- High acid concentration
- Mixing of the milk and acid too slowly
- Using too much acid

5. Calculation of solids-not-fat

The content of milk solids-not-fat (SNF) is calculated from the butterfat content and corrected lactometer reading. Where raw milk is suspected to be adulterated, the SNF contents of genuine and suspect milk samples can be used to determine the level of adulteration with water or other substances using several formulas, though

the results obtained are only approximate. The lactometer reading must be taken when the fat is in a liquid state so the milk is heated briefly to 40°C then cooled to the lactometer calibration temperature. If the fat is partially solid, the lactometer readings will be approximately one degree higher than if the fat is melted.

Formula for whole milk

$$\% \text{ SNF} = (0.2 \times \% \text{ butterfat}) + (0.25 \times °\text{L}) + 0.48 \text{ or}$$

$$\% \text{ SNF} = \% \text{ butterfat}/5 + °\text{L}/4 + 0.48$$

The content of total solids (TS) may be calculated as follows:

Richmond's formula

$$\% \text{ TS} = °\text{L}/4 + (1.2 \times \% \text{ butterfat}) + 0.14$$

British standard formula

$$\% \text{ TS} = °\text{L}/4 + (1.22 \times \% \text{ butterfat}) + 0.72$$

$$\% \text{ adulteration} = \frac{\%\text{SNF}_G - \%\text{ SNF}_S}{\%\text{ SNF}_G}$$

or

$$\% \text{ adulteration} = \frac{\%\text{ TS}_G - \%\text{ TS}_S}{\%\text{TS}_G}$$

where 'G' and 'S' stand for genuine and suspect sample, respectively.

The TS content can be more accurately determined by the reference method of oven drying at 105°C in acid-washed sand for 12 hours. The SNF content is then calculated by difference (% TS minus % butterfat).

6. Determination of freezing point

The freezing point is regarded as the most constant of all measurable properties of milk. The slightest adulteration of whole milk with water will cause a detectable increase in freezing point from its normal value of minus 0.54°C. The increase in freezing point is directly proportional to the level of dilution with water. Determining the freezing point of milk is thus an accurate and reliable method of testing for adulteration of milk by addition of water, and establishing the amount of water added. Conversely, souring of milk or adding solids to it will lower the freezing point significantly. The freezing point of milk is also affected by vacuum treatment, sterilisation or freezing.

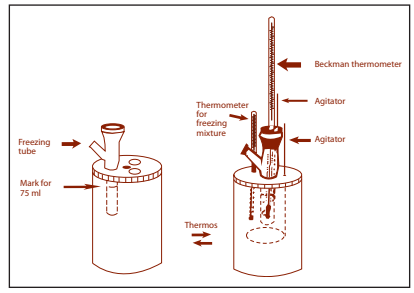


Figure 4: Cryoscope for determination of freezing point

Apparatus and reagents

Thermometer on which difference of 1/100°C can be read

Test tube (100–120 ml)

Volumetric flasks (100 ml)

Laboratory balance

Agitator

Bucket

Analytical grade sucrose

Procedure

1. Prepare the milk sample by heating it to 40°C, mixing gently and then cooling.
2. Prepare the freezing mixture by dissolving 80 g of sodium chloride in one litre of water in a bucket containing 3 kg finely crushed ice. The temperature of this solution should be between minus 3 and minus 5°C.

3. Transfer 75 ml of the milk to a test tube, cool it first in ice water and then in the freezing mixture. Place a thermometer in the milk and continuously shake the milk vigorously while noting the change of temperature.

4. At first the temperature decreases steadily (sub-cooling) then rises suddenly (crystallisation) and thereafter remains constant for some time. This is the freezing temperature of the milk. Read and record the freezing temperature.

5. Dissolve exactly 7 g of sucrose in 100 ml of distilled water in a volumetric flask. This solution has a freezing point of -0.422°C. Similarly, dissolve exactly 10 g sucrose in 100 ml of distilled water. This solution has a freezing point of -0.621°C. The weighing of sucrose and measuring of distilled water must be done very accurately.

6. The thermometer must be carefully cleaned after each use.

Calculation of the freezing point

$$\text{Freezing point} = \frac{-(a - b) \times 0.199 + 0.442}{c - b}$$

Where a = freezing point of milk sample

b = freezing point of calibrating solution containing 7 g sucrose

c = freezing point of calibrating solution containing 10 g sucrose

Estimation of per cent water added to milk

$$\text{Per cent added water} = \frac{-0.54 \times 100}{\text{freezing point of sample}} - 100$$

Exercise: Calculate the amount of water added to a sample of milk if its freezing point is found to be –0.47°C.

7. Inhibitor test

Raw milk may contain residues of antibiotics and other chemical compounds which, if present in significant quantities, can inhibit the growth of lactic acid starter cultures used in the manufacture of fermented milk products.

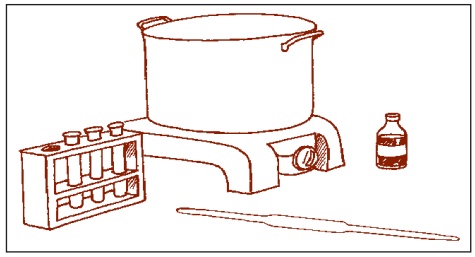


Figure 5: Apparatus for inhibitor test

Principle of the test

The suspected milk sample is fermented with a starter culture and the level of developed acidity in the milk is checked after a three-hour incubation period. The value of titratable acidity obtained is compared with that of a similarly fermented sample which is known to be free from any inhibitory substances.

Materials

Test tubes

Starter culture

1 ml pipette

Water bath

Procedure

1. Fill three test tubes with 10 ml each of the sample to be tested and three test tubes with normal milk.
2. Heat all the tubes to 90°C by placing them in a boiling water bath for 3 to 5 minutes.
3. Assign two tubes (sample and control) to each of three optimum incubation temperatures of the starter cultures: 30, 37 and 42°C.

4. Add 1 ml of starter culture to each test tube, mix and incubate for three hours.
5. At hourly intervals, measure and record the titratable acidity of the sample and control.

Interpretation

A lower titratable acidity in the sample than the control indicates residues of antibiotics or other inhibitory substances in the milk sample.

8. Phosphatase test

The enzyme phosphatase in milk is destroyed by the temperature-time conditions used for pasteurisation (63°C for 30 minutes or 72°C for 15 seconds). Detection of the enzyme phosphatase indicates inadequate pasteurisation of milk and thus some degree of risk of pathogen infection.

Apparatus

Test tubes

Pipettes (1 and 5 ml)

Volumetric flask (100 and 500 ml)

37°C water bath

All glassware must be rinsed in chromic acid solution and boiled in water for 30 minutes before use.

Reagents

Buffer solution (0.75 g anhydrous sodium carbonate and 1.75 g sodium bicarbonate in 500ml distilled water)

Buffer-substrate solution prepared as follows:

- Measure 0.15 g of di-sodium para-nitrophenylphosphate (substrate) into a 100 ml volumetric flask and make up to 100 ml with the buffer solution.

- Store the buffer-substrate solution in a refrigerator and protected from light. It should not be used after one week.

Procedure

1. Pipette 5 ml of the buffer-substrate solution into a test tube, followed by 1 ml of the milk sample. Stopper the tube, mix the contents well and place the tube in the water bath at 37°C.
2. Prepare a blank tube as above but with boiled milk from the same batch as the test sample.
3. Incubate both tubes at 37°C for two hours.
4. Remove the tubes from the water bath and mix the contents thoroughly.
5. Place the sample against the blank in an 'all purposes' Lovibond comparator with APTW disc and rotate the disc until the colour of the test sample is matched.
6. Read and record the disc number.

Interpretation

Disc reading after two hours' incubation at 37°C	Remarks
0 to 10	Properly pasteurised
11 to 18	Slightly under-pasteurised
19 to 42	Under-pasteurised
Over 42	Not pasteurised

9. Peroxidase test

Principle of the test

The enzyme peroxidase is part of the lactoperoxidase system, a natural antibacterial system that is active in raw milk during the first three hours after milking. Peroxidase is not inactivated by pasteurisation conditions but is destroyed at 75–80°C. Thus,

the absence of peroxidase in pasteurised milk indicates that the milk was boiled or over-heated during pasteurisation. Peroxidase catalyses the oxidation of peroxides to other substances in the following reaction:

$$\underset{\text{(Light brown-blue colour)}}{\text{Para-phenylene-diamine} + H_2O_2} \xrightarrow{\text{Peroxidase}} \underset{\text{(Dark blue colour)}}{\text{Oxidised para-phenylene-diamene} + H_2O}$$

Procedure and interpretation

1. Add a few drops of hydrogen peroxide and a pinch of para-phenylene-diamine to 10 ml of the milk sample at approximately 20°C.
2. Shake gently after addition.
3. Development of a dark blue colour within half a minute indicates the presence of peroxidase in the sample and the milk has not been boiled.

10. Brucella milk ring test

Brucellosis, a milk-borne disease, is caused by the pathogen *Brucella abortus*. Humans can contract the disease by drinking unpasteurised milk from infected cows.

Principle of the test

The *Brucella* Milk Ring Test (MRT) detects the presence of *Brucella* antibodies in milk and is useful for periodic screening of accredited dairy herds and in identifying potentially infected herds. The test depends on the presence of:

- The fat globule agglutinin that is responsible for causing the fat globules to cluster and rise to the top. The agglutinin is destroyed by heat and violent agitation of milk.
- *Brucella* antibodies in the milk.

Antibodies of *Brucella abortus* are detected by adding to the milk a *Brucella* antigen which has been stained with haematoxylin. The antigen and antibodies (if present) form a complex that adheres to the fat globules and rises with them, forming a blue-coloured layer of cream. If there are no antibodies present, the stained *Brucella* antigen remains suspended in the milk column below a white layer of cream.

Procedure

1. Collect a 250 ml sample of milk from a bulk tank or can into a sample tube. The sample may be stored at 4°C for up to two weeks. Ensure the sample is at room temperature before testing.

2. Gently mix the milk in the sample tube to ensure even distribution of the

Colour of cream ring	Colour of milk column	MRT reading
Blue	White	+++
Blue	Slightly white	++
Blue	Blue	+
Slightly bluer than or same as column	Blue	±
White	Blue	–

Key:

+++ to ± Positive for *Brucella*

– Negative for *Brucella*

