

Agrodok 36

**Preparation of dairy
products**

Pauline Ebing
Karin Rutgers

© Agromisa Foundation, Wageningen, 2003.

All rights reserved. No part of this book may be reproduced in any form, by print, photocopy, microfilm or any other means, without written permission from the publisher.

First English edition: 1985

Second (revised) edition: 1991

Third edition: 1996

Fourth edition: 2003

Authors: Pauline Ebing, Karin Rutgers

Editors: Rogier Muller, Matty weijnenburg

Translation: W.J. Guijt

Printed by: STOAS Digigrafi, Wageningen, the Netherlands

ISBN: 90-77073-80-9

NUGI: 835

Foreword

This Agrodok is meant to serve as a manual for those who want to start small-scale preparation of dairy products in developing countries. The booklet introduces the reader to small-scale dairy production using simple techniques. It also gives an idea of the opportunities available to earn some income through cheese making.

Locally there is often much knowledge available on the preparation of dairy products. We would advise you to get acquainted with such methods in your area before starting on your own. We would also suggest you do not introduce Western dairy products if there is no need to do so, especially if local dairy products are already being made.

The authors do not have any personal experience in preparing dairy products in the tropics, but have used information provided by J.C.T. van den Berg, who has had much experience with factory preparation of dairy products in the tropics.

The recipes described in this Agrodok have been taken from various books. We would greatly appreciate it if you would write us about your experiences with the recipes in this book, and with information on other local recipes. Where possible, they will be included in a future revised edition.

We would like to express our thanks to J.C.T. van den Berg of the Wageningen Agricultural University in the Netherlands for his assistance and to all others who have helped write, illustrate and edit this booklet.

Wageningen, June 1985

Karin Rutgers
Pauline Ebing

For the third edition the illustrations and the lay out have been improved.

Wageningen, April 1996

The editors

Contents

1	Introduction	6
1.1	What is this booklet all about?	6
1.2	Why process milk?	6
1.3	Problems arising during small-scale processing of milk in the tropics	7
2	The significance of milk and dairy products in the human diet	9
2.1	Milk as food	9
2.2	Composition and characteristics of various types of milk	11
2.3	Infant nutrition	12
2.4	Lactose intolerance	13
2.5	Milk and milk products in the diet	13
3	Hygiene	15
3.1	Deterioration due to micro-organisms	15
3.2	Yeasts and fungi	16
3.3	Bacteria	17
3.4	Other causes for the deterioration and spoilage of milk	18
3.5	Hygiene during production, storage and processing	19
3.6	Cleaning and disinfection	21
4	Processing techniques	23
4.1	Pasteurization	23
4.2	Cooling	26
4.3	Souring	27
4.4	Creaming	27
5	Starter cultures	29
5.1	The development of lactic acid bacteria	29
5.2	Preparation and storage of the starter culture	31
5.3	Preparation of milk culture using a powder	32
5.4	Activation stage and inoculating the culture	32

5.5	Maturing stage	32
5.6	How to maintain the culture	34
5.7	Storage of the culture	34
5.8	Activity of the culture	34
5.9	Preparing your own culture	35
6	Recipes	38
6.1	Cream	39
6.2	Sour cream	40
6.3	Butter	41
6.4	Buttermilk	45
6.5	Ghee	45
6.6	Koa or Khoa	46
6.7	Rabi	46
6.8	Yoghurt	46
6.9	Kefir	49
7	Cheese	51
7.1	Utensils for making cheese	52
7.2	The quality of the milk used to make cheese	56
7.3	Coagulation of the milk	56
7.4	Separating curd and whey	59
7.5	Ripening of the cheese	61
7.6	Cheese recipes	62
	Further reading	70
	Useful addresses	72
	Appendix 1: Measures	74

1 Introduction

1.1 What is this booklet all about?

Livestock in the tropics is usually kept for various reasons such as traction, meat, wool, hair, skins and dung which, when dried, can be used as fuel. Milk is often no more than a by-product of animal husbandry, although it is a valuable foodstuff. Furthermore, keeping livestock can be a way of saving. In case of an emergency, animals can be sold to provide money. As such, animal husbandry is also a kind of insurance against, for example, disease and crop failure.

It is not by accident that a certain kind of milk-producing animal is kept in a specific area. This is due to climatic conditions, locally prevalent diseases, available fodder, the possibilities of the owner to take risks, additional tasks that the animal is expected to do, religion and tradition and the preference for products which the animal produces.

Keeping dairy animals often leads to a surplus of milk. If milk production is higher than consumption in a certain area, the surplus can either be sold on the market, or it can be processed so that it does not go off. If the quantity of milk to be processed is small (up to 100 litres at a time), it is considered to be small-scale. This Agrodok deals with the small-scale processing of milk using simple equipment.

1.2 Why process milk?

Some of the reasons for processing milk into milk products are the following:

- Some dairy products can be kept longer than fresh milk, therefore the milk does not have to be consumed immediately.
- The demand for fresh milk may be limited, there may be more interest in milk products.
- If the daily amount of fresh milk for sale is limited, it may be more economical to process the milk into less perishable products, store them, and sell them later in greater quantities.

- There may be no market for fresh milk close by, and only preserved products can be sold at markets at a greater distance.
- Greater financial gain may be obtained.

Apart from these reasons, it should also be realized that many groups of people in Asia and in Africa cannot or can hardly consume milk because of so-called lactose intolerance. Lactose intolerance implies that the body is almost or entirely unable to digest the milk sugar, lactose, which is found in milk. Only small amounts of milk (up to 200 ml) consumed several times a day can be digested. Dairy products in which a proportion of the milk sugar is converted during production, such as cheese, yoghurt and buttermilk, do not cause many problems in this respect.

When processing surplus milk, one must consider whether it is profitable to do so. The processing is not always easy and there may be losses. For example, a waste product of cheese making is whey, which contains many valuable nutrients. If the whey is not used, a valuable part of the milk is lost. Furthermore, while milk is being processed quality deterioration may occur and it can go off. Only when milk is drunk immediately can you be sure that nothing is lost.

1.3 Problems arising during small-scale processing of milk in the tropics

Small-scale processing of milk means the processing of small quantities of milk, up to 100 litres at a time, using simple implements and as little extra equipment as possible. Processing milk in the tropics can give certain problems because of the high temperatures and high relative humidity often found in the tropics. This presents special problems in choosing the right kind of dairy products, in which their storage life must be taken into consideration.

High temperatures are bad for cheese making, especially for maturing cheeses. The quality of milk can also deteriorate rapidly and it can turn sour. Therefore, it is very important than anyone handling milk should pay great attention to hygiene. Lack of cleanliness can

contaminate milk with bacteria which turn it sour and reduce its storage life.

Cleaning and sterilizing dairy utensils and equipment is essential. High temperatures cause the bacteria already present in the milk to multiply quickly. Milk sugar then turns sour, leading to the curdling of milk. However, the lactic acid bacteria which cause milk to turn sour are not harmful to man. The prevention of infection is often difficult when milk is collected from various places and processed centrally.

All the milk is contaminated when even a small quantity of infected milk is added.

A further problem is the lack of equipment. One has to try to manage with simple dairy equipment, but there is not much which can be bought for small-scale milk processing. Electricity is usually not available so electric equipment (e.g. for cooling) cannot be used unless a generator is installed. Additives such as rennet for cheese making are often difficult to obtain in the tropics.

The following chapters discuss the importance of milk in the diet, hygiene and milk processing techniques. The second part of the book gives guidelines for heating, cooling and evaporation, and the making of cream, butter, ghee, sour milk products and cheese.

2 The significance of milk and dairy products in the human diet

2.1 Milk as food

Milk contains substances which are essential to man such as proteins, carbohydrates, fat, water, all the B-vitamins, vitamin A, calcium and phosphorus (see Figure 1). It also provides energy. An important protein in milk is casein. Milk protein is of a high quality, meaning that a large part of the protein can be used efficiently by the human body to make human protein. Proteins in various other foodstuffs have a complementary effect. In combination with cereals, potatoes, meat, egg or nuts in one meal, an even greater percentage of the milk protein can be used by the body.

Apart from milk protein, there are other animal protein sources such as fish and meat. Vegetable protein, which is also important in making the body's proteins, is found in cereals and pulses. Protein is needed by the body for growth, replacement of worn-out body proteins and the production of compounds that the body needs.

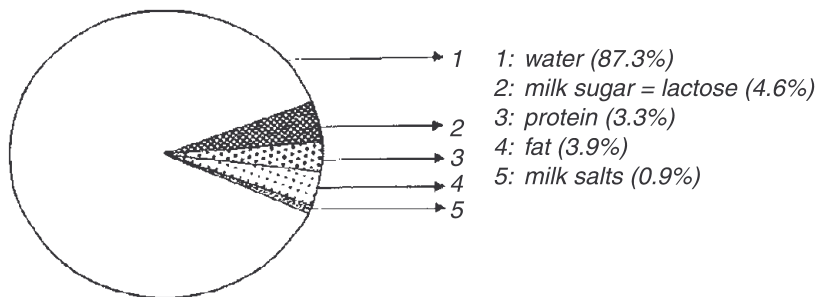


Figure 1: Composition of cow's milk.

Milk sugar (lactose) gives milk its sweet taste. Lactose is a carbohydrate, a substance necessary to keep the body going. Our bodies burn carbohydrates in the same way an oven burns wood. Through this

combustion, energy is released which is used by our bodies for many kinds of activities.

Milk fat is present in the form of small fat globules which are lighter than the other constituents in milk. When cow's milk is allowed to stand, these globules collect on top of the milk and form a layer of cream. Buffalo milk forms some cream on top, but other kinds of milk, such as that of sheep and goats, hardly form a layer of fat at all. For these types of milk one needs to separate the cream from the milk. Milk fat is easy to digest. The body uses fat as a fuel or stores it as fat reserves.

Milk is also an important source of vitamins and minerals. It contains large quantities of calcium, which can easily be absorbed by the body after digestion and is important for the formation of bones (the skeleton). Milk is also an important source of vitamin B2 (Riboflavin), but there is little vitamin C in milk. Therefore a person's diet must also include vegetables and fruits in order to ensure sufficient vitamin C.

Milk is able to compensate for a lack of certain nutrients in a monotonous diet because of the great diversity of nutrients in milk and the high value of milk protein. It can therefore greatly improve the quality of the diet. Products derived from milk contain these nutrients to a greater or lesser extent. Milk is especially desirable for vulnerable groups, for instance babies, toddlers, children and pregnant and nursing mothers.

Iron is present in large quantities in animal products (especially in liver and kidney), green vegetables and pulses, and in smaller quantities in cereals, nuts, eggs, fish and tubers (such as yam and potatoes).

Always strive for a healthy, varied diet, which apart from milk also includes cereals, pulses, vegetables, fruits and if possible meat or fish. The various types of milk differ, amongst other things, in nutritional value. In the next pages this is dealt with in more detail.

2.2 Composition and characteristics of various types of milk

The composition of mother's milk and milk from cow, buffalo, goat, sheep, camel, donkey and lama is shown in Table 1.

Apart from the differences in cream formation there are other differences between the various kinds of milk. There is a lot of pro-vitamin A in cow's milk, giving it its yellow colour, but not in buffalo, goat's or sheep's milk. This is why only cow's milk is yellow in colour. Buffalo milk curdles sooner than cow's milk. Unless the preparation is adjusted, cheese made from buffalo milk will mature more slowly and have a drier consistency than cheese made from cow's milk. Goat's milk can have an unpleasant smell; this can be prevented by boiling the milk as soon as possible after milking.

Cow's milk accounts for 91% of the world's milk production and buffalo, goat's and sheep's milk account for 5.9%, 1.6% and 1.7% respectively.

Table 1: Composition of various types of milk.

(Source: FAO Nutritional Studies 27)

Milk source	fat (%)	protein (%)	lactose (%)	calcium (%)	energy (cal/100g)
mother's milk	4.6	1.2	7.0	0.0	73
Friesian cow	3.5	3.3	4.6	0.1	62
Guernsey cow	4.7	3.2	4.7	0.1	75
Indian buffalo	7.5	3.8	4.9	0.2	100
goat	4.5	3.3	4.4	0.1	71
sheep	7.5	5.6	4.4	0.2	105
mare	1.6	2.2	6.0	0.1	47
donkey	1.5	2.1	6.2	0.1	46
camel	4.2	3.7	4.1	?	70
lama	3.2	3.9	5.3	?	65

Although there are enormous regional differences we can generally say that, if it is to be drunk, milk from cows or buffaloes is preferred to that of goats and sheep. Goat's and sheep's milk are more popular for making cheese and soured milk products (especially sheep's milk). Camel's milk is usually drunk. Mother's milk is the most ideal food

for a suckling infant. Nonetheless, many substitutes have been developed which find a ready demand. We shall pay more attention to baby nutrition in the next paragraph.

2.3 Infant nutrition

Breastfeeding is the healthiest and most hygienic way to feed a baby. Mother's milk is best suited to the needs of a child, and contains certain substances which protect an infant against infectious diseases. All the nutrients a baby needs, except iron and vitamin C, are to be found in sufficient quantities in mother's milk. At birth, a baby has a store of iron in its liver which it uses up during its first 6 month. Any kind of supplementary feeding is only necessary after 3 months, as the mother's milk then no longer supplies all the nutrients the infant needs. Fruit juice and mashed fruit provide additional vitamin C, which the infant then needs. Supplementary feeding of energy giving foods is also desirable. Mixing small quantities of milk-powder into mashed food can considerably improve the food's value (especially the value of its protein).

It is advisable to continue breastfeeding as long as possible because mother's milk is often the only source of animal protein for a baby. If the mother cannot give any breastfeeding, does not have enough milk or dies, bottle feeding is a solution and the best substitute. However, in practice often too much water is added to the (artificial) baby food, which is usually bought in powder form. It becomes too watery and is therefore not nutritious enough. Moreover, artificial foods are costly and require good hygiene. Dilution with water is often a cause of infection because the available water may be polluted. Water used for bottle feeding must first be boiled, but sterilizing water by boiling it uses a lot of fuel which is often in short supply. By using a cup or spoon it is easier to maintain the necessary cleanliness than when using a bottle.

Money might be better spent on essential necessities of life than on artificial infant food if the latter is not strictly necessary. If a baby cannot tolerate milk, you will be forced to use milk products which do

not contain lactose. This is the case with inherited lactose intolerance. We shall discuss this in more detail.

2.4 Lactose intolerance

Lactose intolerance means that the human body is almost, or entirely, unable to digest the milk sugar, lactose, which is present in milk because the body lacks the enzyme lactase. The undigested lactose may cause, for instance, milk acid to be formed and with it the production of gas. Consumption of larger quantities of milk causes flatulence, stomach cramps and diarrhoea. There are different forms of lactose intolerance:

➤ Congenital lactose intolerance.

In this case, a baby cannot tolerate milk because it lacks the enzyme lactase, necessary for the conversion of lactose

➤ Lactose intolerance in children (2-5 years old).

From the age of 2, lactase activity in a child decreases and he/she may have problems due to insufficient lactase by the time he/she is 4-5 years old. Consumption of small quantities of milk (one glass at a time) usually does not cause any problems. It is also possible to prevent problems by eating milk products in which part of the milk sugar has been converted, such as cheese, yoghurt and buttermilk.

➤ Lactose intolerance as a result of intestinal disease and/or malnutrition.

Especially in babies and toddlers. The activity of the lactase is temporarily decreased. Lactose-free milk products must be used for a short time. Cheese, in which milk sugar has been converted, is also suitable.

Apart from lactose intolerance, the use of milk also depends on other factors, which we will now discuss.

2.5 Milk and milk products in the diet

The diet is the way people feed themselves and the foodstuffs they use to do so. This is strongly influenced by the traditions and religion of

people, their economic position, their place in society and the possibilities offered by their natural surroundings. It is not surprising that each group of people has its own diet. The use of milk and milk products can also be looked at when examining the diet.

Here are a few examples of how the factors mentioned above can influence the place and form of milk and milk products in the diet.

- The cow is a sacred animal in India, therefore the rennet used in cheese making may not be taken from a calf's stomach.
- When milk or milk products have to be bought, money is needed.
- In densely populated areas, people are forced to use all available land for crops which give a maximum yield, or crops which can be directly consumed by the people. This limits the land available for dairy farming.
- It may not be possible to keep cattle in certain regions, e.g. the humid tropics, due to the natural environment. For example, in humid areas of West Africa cattle are the host of the tse-tse fly which transmits sleeping sickness and therefore cannot be kept.

For these reasons, milk and milk products in the diet can be of greater or lesser importance in one area or another. Economic and social situations are especially subject to change and dietary patterns change with them.

New foodstuffs may be introduced which will (partly) substitute others. Adoption of new products is often no easy matter; sometimes century old traditions may have to change. Also taste and other characteristics such as texture are important in the acceptance of new kinds of food. Something which may be considered to be very tasty in one place may not be appreciated elsewhere.

3 Hygiene

Milk should be handled with care. There are several factors that can make milk go off and unsuitable for further consumption. These include:

- The presence of too many micro-organisms in the milk.
- Contamination by sick animals (tuberculosis, udder infection) and/or people.
- Bacterial and/or chemical conversion of certain substances in the milk.
- An unusual flavour or smell due to absorption of substances which do not normally occur in milk (cleaning products, disinfectants, antibiotics, pesticides).

The above mentioned factors always cause some deterioration of milk. In some cases it is only the flavour which is affected, but usually the structure and smell of milk also changes.

We will first discuss the way organisms cause the deterioration of milk. Then precautions which can be taken to minimize the impact of these factors will be explained, and some suggestions for cleaning and sterilizing will be given.

3.1 Deterioration due to micro-organisms

It is more than likely that raw milk contains many micro-organisms such as bacteria, fungi, yeasts, etc. Micro-organisms are small and cannot be seen with the naked eye. They are found everywhere: in the air, water, soil and even in small quantities in food and milk. Once milk has been contaminated by micro-organisms, they multiply very rapidly. This “infection” as we call it, is the transmission of living, harmful microorganisms from one place (e.g. the hands of people) to another (milk).

Many micro-organisms can cause diseases like foot and mouth disease, salmonella infection, dysentery, tuberculosis (in man and in

animals), diphtheria and scarlet fever. Due to inadequate hygiene, diseases can be transmitted from person/animal to person.

Temperature plays an important role during the development of micro-organisms. Their growth starts at a temperature of 4°C. It is therefore very important to store milk or milk products below or at 4°C, otherwise deterioration will take place rapidly. Above 20°C, bacteria multiply at an incredible speed.

Most micro-organisms are killed during pasteurization at a temperature above 72°C for a period of 1-20 seconds, but a few will survive intense heating. This is one of the reasons why boiled milk sometimes shows signs of infection, such as an unpleasant taste or the formation of harmful ingredients. Some of the micro-organisms that can spoil milk are fungi and yeasts.

3.2 Yeasts and fungi

Yeasts are micro-organisms that can turn sugars into gas and other substances. They are about 5-10 times larger than bacteria. Reproduction usually takes place through budding, division or through spores. Yeasts usually grow in an acid environment, do not need oxygen, and can withstand high concentrations of salts. In dairy products, yeasts are usually found in soured products like buttermilk, sour whey, butter and in or on cheese. When present in large numbers, they can cause undesirable conversions of the product. These particular yeasts can produce gas and alcohol from the milk sugar in buttermilk and sour whey. In butter they can cause the breakdown of fats, which reduces the quality of butter.

Fungi are string-like micro-organisms, large enough to be seen with the naked eye. For their development they need atmospheric oxygen, and they thrive best in humid and acid conditions. Fungi disperse themselves easily through the air and can often be found on poorly maintained ceilings and walls. Their mobility makes them an important source of infection. Fungi can be seen on the surface of butter or cheese in the form of coloured spots. The growth of fungi on the rind of cheese can be prevented by covering it with cheese wax, plastic or (sunflower) oil. However, it must be noted that special fungi

that are totally harmless are used for the production of certain kinds of cheese.

Cells and spores of fungi and yeasts can be destroyed by heating the milk for a short period to about 72°C.

3.3 Bacteria

Bacteria are single-cell micro-organisms that multiply by cell division. Milk or any milk product contains many different kinds of bacteria. Environmental conditions (such as acidity, temperature or amount of oxygen) can change, making conditions less attractive for one kind of bacteria but at the same time creating ideal conditions for another type. This is why some kind of bacteria will always be found in milk or milk products.

An exception is milk-powder which has not been dissolved in water. Deterioration of the quality of milk-powder does not continue after a particular type of bacteria has died, and so the number of bacteria in uncontaminated milk-powder decreases with time.

Bacteria found in milk can be divided into two groups: useful and harmful. Lactic acid bacteria (e.g. *Streptococcus lactis*) are useful bacteria. The lactic acid they produce is not harmful to man and gives milk a fresh, sour taste. This sour milk can be very useful. When producing certain dairy products like soured milk, yoghurt and cheese, good use is made of these specific properties (see Chapter 5).

Milk can also turn bad without turning sour first. In this case, certain disease causing bacteria develop and whey separates from the milk. This usually happens after long storage. The smell is unpleasant and the taste bitter. Such milk should not be consumed.

There are a number of reasons why bacteria can be harmful:

- Some bacteria cause certain diseases, others produce poisonous substances that lead to illness. The destruction of this type of bacteria (through, for instance, heating) does not necessarily mean the simultaneous destruction of those poisonous substances.
- Bacteria can cause the breakdown of certain ingredients in milk, reducing its nutritional value and giving it a bad smell and flavour.

3.4 Other causes for the deterioration and spoilage of milk

Milk will also deteriorate because of:

- The breakdown of vitamins and fats.
- The presence of foreign substances.

Vitamins and fats

Light causes the breakdown of vitamins in milk. It mainly affects the important B-vitamins; up to 80% of this vitamin can be broken down under the influence of sunlight. The combination of oxygen and light will cause the breakdown of vitamin C. It is therefore important to store milk in a dark place. Violent movement of milk, with the resulting addition of oxygen into the milk, should also be avoided as milk fat can turn rancid in the presence of oxygen. Vitamin A, which is soluble in fat, is also susceptible to the influence of oxygen.

Some vitamins are adversely affected by heating, especially in the presence of oxygen. However, the heating of milk is necessary in order to destroy any harmful micro-organisms. The subsequent reduction of vitamin A simply has to be accepted.

The combination of light and copper in milk causes an increased breakdown of certain substances. Milk and certain dairy products, such as butter, can acquire an unusual taste due to this. We therefore advise you not to use copper utensils in the preparation of these products.

Foreign substances

Foreign substances that enter milk can be dangerous to our health. They can also cause unpleasant flavours and smells, reducing the suitability of milk for further processing. A few of these products are: cleaning and disinfecting agents, medications, pesticides and pieces of metal. The feed given to animals, such as tubers and cabbage, can also influence the taste of their milk. This can be avoided by feeding after milking.

Good hygiene can reduce deterioration. How to achieve a good level of hygiene will be discussed in the following pages.

3.5 Hygiene during production, storage and processing

Infection occurs when harmful micro-organisms enter milk. Possible sources of infection during production, storage and processing are:

- The animal itself.
- Conditions in the milking place (floor, dung, dust etc.).
- The person milking.
- Insects (e.g. flies, cockroaches).
- Utensils and equipment used during processing.

It must be clear by now that it is no easy task to keep undesired micro-organisms out of milk. A lot depends on the person milking, the care taken of animals and the cleanliness of utensils. If everything is kept as clean as possible, very few micro-organisms will enter milk. In addition, milk should be kept cool. Good hygiene is of major importance.

Hygiene during production

There are several possible causes of infection during milking. In a normal healthy cow, few bacteria are found in the udder and teats. Cows possess various mechanisms to prevent the entry of bacteria.

To avoid problems while milking, it is important that an animal grows accustomed to the action. It will then know that it will be milked, and will react positively to it. Such positive behaviour can start if, for instance, it hears milk cans clanging, feels its udder being cleaned, etc. The animal is then easier to milk and gives more milk.

When a cow has an udder infection (mastitis), its milk will be contaminated and contain pus and sometimes blood. *Milk from these animals should not be used in any way.* Mastitis can be prevented by maintaining good hygiene and avoiding injury to the teats during milking. An infected udder is not always easy to see and is very painful when touched. When an udder infection occurs, it is advisable to leave a suckling calf with the infected animal. The udder is then frequently suckled dry, and the amount of micro-organisms in the udder is thus reduced. Milking an infected udder by machine or by hand is often painful and can further damage the udder.

Bacteria can be transferred from the skin or teats to the milk, even with healthy dairy cattle. It is therefore important to clean the udder before milking. Before milking, wipe the udder clean with a dry, clean, preferably disposable cloth to prevent infection. The disadvantage of using a wet cloth is that bacteria on the udder or teats are soaked off which can then contaminate the milk. If the teats or udder are really dirty, they must first be washed with clean water and then dried with a clean cloth. Cleaning the udder improves the cleanliness of the milk and makes milking easier. Skin and hair can also be sources of infection.

Bacteria can also enter milk via the air. Do not feed animals first before milking. See to it that the floor is clean, and be careful when clearing dung, mud or dust. A clean milking place and fresh surrounding air are essential to maintaining good hygiene.

Insects such as flies and cockroaches can also be sources of infection. Try to control them as they can carry many bacteria and viruses.

When milking, the milk is caught in a pail or bucket. Dirty milking equipment is the main source of infection of milk. Bacteria will multiply there if the equipment is not cleaned properly. Use pails and buckets that are smooth on the inside, for instance seamless metal buckets.

All milking equipment should be thoroughly cleaned with clean water immediately after each use. Use soap or other disinfectants if necessary. Make sure that the water used is clean. If you are in doubt, boil it for several minutes or add chlorine.

The person milking plays the most important part in maintaining proper hygiene during production. He or she keeps an eye on the condition of the animal, chooses the milking place and cleans all the equipment. He/she should have clean hands and wear clean clothes. If the milker suffers from tuberculosis, salmonella infection, dysentery or some other disease, the risk of infection becomes very high; it would be wise to have somebody else take over. This is also the case if the milker has open wounds or ulcers.

Hygiene during storage and processing

By now you should know that milk should be processed as quickly as possible after milking and that it should be properly stored in order to minimize its chances of spoiling.

It is best to filter fresh milk through a filter or clean cloth. This will remove the largest particles that might have entered the milk. Clean or replace the cloth during filtering or filter several times. The cloth should be thoroughly cleaned after use and then left to dry in the sun. In tropical conditions, raw milk, i.e. non-pasteurized milk, goes off within a few hours. It must therefore be quickly pasteurized and then cooled to a temperature of 4°C if possible.

Properly pasteurized and cooled milk can be kept for a few days, even in a warm climate. If you are not able to cool milk below 10°C, then do not mix different batches. Even if the older milk is still good, you will end up with an increase in bacterial growth and reduction of the overall quality. Use clean equipment for storage. Containers that are clear, such as glass, should be stored in the dark as light reduces the quality of milk. Clean or disinfect your equipment with clean water.

3.6 Cleaning and disinfection

Cleaning utensils must be done in such a way that all dirt, food leftovers and micro-organisms are removed from the surface of the equipment. Dirty saucepans, jugs, milking equipment and utensils should be cleaned immediately after use. Washing soda (sodium carbonate) dissolved in hot water is an excellent cleaning agent.

It is necessary to disinfect equipment shortly before use, in order to kill any remaining harmful micro-organisms. You can use a chloride solution such as bleach (sodium hypochlorite).

A proper way of cleaning and disinfecting your equipment is the following:

- Rinse well with water.
- Scrub the tools in a hot soda solution (1½ tablespoons of soda to 5 litres of water), using a small amount of water to dissolve the soda before adding it to the rest of the water.
- Rinse well with hot water.

- Buckets, tubs, etc. should be turned upside down on a rack during storage; the water can then drain and no dirt or dust can enter.
- Disinfect in a chloride (bleach) solution shortly before use (2 tablespoons of bleach per 4.5 litres of water).
- Rinse again with clean, hot water (60-100°C) to remove all remaining disinfectants. This is important and should not be forgotten!

Note: The bleach will be ineffective if the utensils are not clean in the first place. It is therefore important to clean all your equipment properly before disinfection.

Cleaning agents and disinfectants are chemicals that can irritate the skin. Direct contact should therefore be avoided; wear gloves, if possible. Take care that cleaning agents and disinfectants do not get into contact with each other as poisonous fumes can be formed. Do not use any disinfectants other than bleach. As cleaning agents and disinfectants are dangerous products they should be locked away in a safe place, where no unauthorized person can get at them. Label the bottles clearly.

Tools or any other equipment made from aluminium should not be washed in a soda solution; soda chemically attacks aluminium. Iron utensils will rust in a chloride solution. It is therefore advisable to use stainless steel equipment, cheesecloth and wooden utensils. Small tools, pots and such like can also be disinfected by leaving them in boiling water for 10 minutes.

If you have no cleaning agents or disinfectants, you can clean your equipment as follows:

- Thoroughly clean the utensils using clean water.
- Rinse with a soap solution.
- Rinse for 10 minutes with boiling water.

4 Processing techniques

Milk can be stored longer if it has been processed. Extended storage is possible if you are able to control the growth of harmful micro-organisms. The processing technique used will determine the storage life of the milk and milk products. The following rules should be followed during the production, storage and processing of milk:

- Always wash your hands and never put them in the milk.
- See to it that all equipment used during processing is properly disinfected and cleaned.
- Take care that no dirt particles or insects enter the milk.
- Do not use copper utensils.
- Do not expose milk to sunlight; store it in a dark place.
- Stir milk as gently as possible to avoid mixing in air.
- The use of a thermometer is recommended.
- Make sure that milk used for consumption has always been boiled or pasteurized.
- Never store raw (i.e. unheated) milk.

The following processing techniques will be dealt with in this chapter:

- pasteurization
- cooling
- souring
- creaming

Heating and cooling are in fact ways to preserve milk, but for convenience we will deal with them under the heading of processing techniques.

4.1 Pasteurization

As you by now know, milk contains certain micro-organisms that can spoil it. These bacteria grow best at temperatures between 10°C and 40°C. It is therefore important to cool milk as quickly as possible.

This can be difficult in the tropics if there are no refrigerators available.

Most harmful bacteria will be destroyed during heating. The most effective temperature depends on the heating time. In other words, heating for a longer period at a lower temperature can be as effective as heating for a shorter period but at a higher temperature.

Pasteurizing improves the safety and storage life of a product, while the loss of vitamins is minimal. A distinction is made between low and high pasteurization (see Table 2). During low pasteurization, the substances which limit the growth of bacteria and which are naturally present in milk remain intact; after high pasteurization, those substances are no longer present. Therefore, although high pasteurization initially kills more bacteria, the resulting milk can usually not be kept as long. Pasteurized milk can be kept for about one week at 4-10°C if no reinfection takes place.

The pasteurization temperature to be used depends on the product to be made from the milk.

- Low pasteurization is used for consumption milk and cheese.
- High pasteurization is used for yoghurt, butter and kefir.

If there is no thermometer to measure the exact temperature, heat the milk to its boiling point.

Table 2: A few examples of temperature-time combinations for pasteurizing milk.

	time	temperature
low pasteurizing	20 minutes	63°C
	3 minutes	68°C
	20 seconds	72°C
high pasteurizing	2 minutes	82°C
	15 seconds	85°C

The following method A is suitable if you are able to accurately control both temperature and time. Methods B and C are more hygienic, but the exact temperature of the milk is unknown. The

combinations of time and temperature in method B and C guarantee a low pasteurising effect.

You will need:

- Raw milk, a heat source, a saucepan with a thick bottom and smooth on the inside, a thermometer and a means of cooling the milk that has been heated.
- For method A: a disinfected (boiled) wooden spoon.
- For method B: glass jars with lids or bottles with tops.
- For method C: plastic bags and sealing equipment.

Method A

Put the milk in a clean saucepan and heat it to 72°C, stirring constantly. Keep the milk at that temperature for at least 20 seconds.

Method B

Clean and disinfect the glass jars with lids or bottles with tops. Fill them with milk and close the lids. Submerge the jars and bottles in a large pan filled with water. Heat everything to 80°C and keep it at that temperature for at least 10 minutes.

Method C

Fill clean plastic bags with milk and seal them. Put the bags in a large pan, fill it with water until they are completely covered, heat to 80°C and keep it at that temperature for about 10 minutes.

When using method A, let the milk cool down as quickly as possible. The best storage temperature is 4°C. The proper storage temperature for a soured milk product or cheese can be found in Chapters 6 and 7. If you are not able to maintain a constant temperature of 80°C, the best alternative is to heat the water in the pan until it boils and keep it boiling for some time. It is important to store the pasteurized or boiled milk at 4°C. At this temperature it can be kept up to one week. Handle the boiled or pasteurized milk with care to prevent reinfection.

4.2 Cooling

Storing milk at a low temperature will greatly reduce the growth of bacteria. Although bacteria develop slower in cold milk, most of them do still multiply. The development of certain specific bacteria is stopped completely.

The best storage temperature is 4°C. If this temperature cannot be achieved, you should store the milk in a dark place at the lowest temperature possible.

Without cooling, raw milk will spoil within a day (see Table 3).

Table 3: Quality of raw milk after storing it for 24 hours at different temperatures and under varying conditions.

storage method: temperature (°C)	very hygienic	hygienic	unhygienic
4	good	good	poor
10	good	poor	poor
20	poor	poor	bad
35	bad	bad	bad

To cool milk, you will need:

Pasteurized or boiled milk, either a can with a lid, a saucepan, a bottle or a dish, two thoroughly cleaned spoons and either a large pan with cold water, a cellar or a refrigerator.

Put the pasteurized or boiled milk in a disinfected container and cover it with a lid or some appropriate cover. Let it cool off as quickly as possible, either in the cellar, the refrigerator or in a large pan with cold water. The best temperature for storage is 4°C. If you use a pan with cold water make sure that no water enters the milk because it would contaminate the milk again. Add ice cubes to the cooling water, if available. Stir both the water and the milk during cooling with a spoon, using different spoons. Figure 2 shows how to cool bottled milk.

As mentioned above, properly pasteurized or boiled milk can be kept for about one week if stored at 4°C. At 10°C it will spoil quickly; if it is 15°C or warmer, it should be consumed the same day (see Table 3).

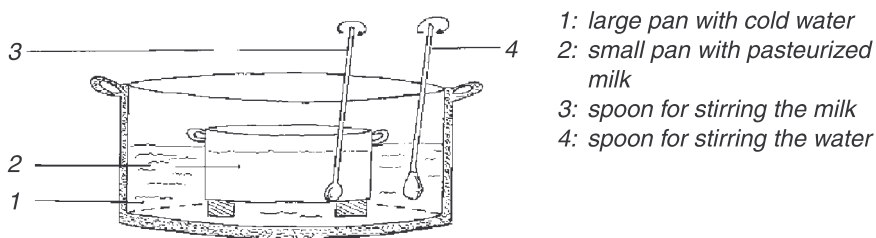


Figure 2: Cooling pasteurized milk.

4.3 Souring

Another way of increasing the shelf-life of milk is to process it into soured milk products. Part of the milk sugar is converted into lactic acid by bacteria (for example: *Bacillus Bulgaricum* or *Strep.lactis*). The milk can be left to sour spontaneously, but then you cannot control which bacteria go to work. It is better to sour the milk with the help of specific mild bacteria (starter culture) after it has been pasteurized. Quality and taste are influenced by the different by-products that the different bacteria produce. Fermented products require high pasteurization or boiling of the milk (see Table 2), except when preparing cheese in which case low pasteurization is needed.

4.4 Creaming

Cream is made from the fat that floats on the surface of cow's milk. A layer of fat forms on the surface of the milk after it has been left to stand for a while. This layer contains 20% fat. The simplest way of collecting it is by skimming it off the top of the milk. Sheep's and goat's milk do not cream easily. You will need a creamer or centrifuge to obtain good results. You should be able to get 1-2 litres of cream from 10 litres of milk.

Cream cannot be kept for long. The skimmed milk which remains after the removal of the cream is still very nutritious. You can either drink it or use it for the production of soured milk or cheese.

Sour cream, soured milk, butter (80% fat) and buttermilk are made by churning milk. One hundred litres of milk with a 4% fat content produces 35 litres of cream, which yields 4 kg of butter. However, butter is not an important product in tropical countries because it melts at high temperatures and is expensive. There is generally little demand for butter.

Butter and cream can be used to make ghee. Ghee keeps better than cream and butter as it contains practically no moisture; it is almost pure milk fat.

5 Starter cultures

In tropical countries it is often difficult to keep milk from spoiling before consumption. One method to avoid this is to make sour milk by adding certain bacteria to the fresh milk. Different kinds of bacteria produce different kinds of sour milk.

The temperature during the souring process also influences the taste of the end product. People have discovered yoghurt, dahi, laban, nono and kumis in this way. You can use milk from cows, goats, sheep, buffaloes, camels or mares. All these different kinds of milk produce differences in taste and consistency.

5.1 The development of lactic acid bacteria

The growth of bacteria shows a specific pattern consisting of the following consecutive stages: adaptation phase (A), a period of rapid multiplication (B), a stabilization period (C) and a decreasing phase (D) (see Figure 3).

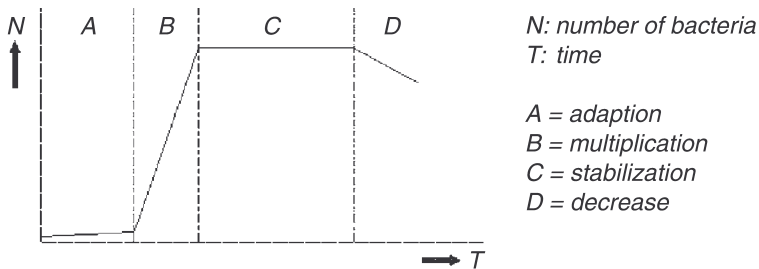


Figure 3: Development of lactic acid bacteria.

During the souring of milk, one can recognize the four growth phases of bacteria. These are:

Adaptation phase

During this period, bacteria, of which only a relatively small number is present, have to adapt to their new environment. Multiplication is still very slow. The length of this period depends on the type of bacteria, their viability, the temperature of the milk and whether there are any bacterial growth inhibiting factors present.

Period of rapid multiplication

The bacteria, after adjusting to their new environment, multiply rapidly and start converting milk sugar (lactose) into milk acid (lactic acid). The milk gets thicker and will taste sour.

Stabilization period

During this stage, the number of bacteria remains constant. The reason for this is that they do not thrive in sour milk because of the partial conversion of milk sugars.

Decrease of bacteria

Due to the exhaustion of the food source and the production of poisonous substances, the bacteria die. This is why you must not wait too long before transferring part of a desirable bacteria culture (inoculation) to fresh milk. If you do, hardly any bacteria will be alive by the time they are added to the fresh milk. Too little lactic acid will then be formed and the desired milk product will not be created. It is therefore important to inoculate fresh milk with a culture as soon as possible. This will also shorten the adaptation period.

Once the milk has soured (due to *Strep.lactis*), it should either be consumed immediately or used for the production of milk products within a very short time. Any delay will allow the sour milk to turn into a product that contains harmful bacteria.

5.2 Preparation and storage of the starter culture

For the production of sour milk you can either let the raw (unheated) milk sour spontaneously or use an additive or culture that contains the appropriate bacteria. This is called a starter culture or souring agent.

During spontaneous souring, the possibility exists that undesirable micro-organisms will contaminate the milk. It is therefore better to use a starter culture which is usually grown in milk. When small quantities are made, a small amount of yoghurt, whey or sour buttermilk can be used as a starter culture. Experience has shown that the use of a starter culture produces a more consistent and better product than that of naturally soured milk.

It is difficult to keep the starter culture fresh and active, especially under tropical conditions and limited resources. The preparation of the culture requires good hygiene and proper temperatures.

Different products require different cultures, for instance yoghurt and cheese. If you can obtain a powder culture, follow the instructions on the package. Once the seal of the package has been broken, the bacteria will not survive for more than two days. For this reason it is recommended you start your own culture and maintain it. That way it is not necessary to buy a fresh starter culture each time you want to make cheese or a soured milk product.

In order to prevent infection, good hygiene is very important. All equipment used should be properly cleaned, disinfected or sterilized and rinsed with boiling water shortly before use. This is very important as any remnants of bleach remaining on the equipment will stop the development of the bacteria needed to produce the desired milk product.

To make a starter culture you will need the following:

Fresh milk (with or without cream), a thermometer, a heat source, a normal size pan with a lid, a small pan with a lid, starter culture powder, a wooden spoon, a place with a constant warm temperature (e.g. a haybox or thermos), a pipette or a small measuring beaker (from the pharmacist) and glass pots that can be closed properly.

5.3 Preparation of milk culture using a powder

Milk used for the production of a culture should be handled under very hygienic conditions. Whole or skimmed milk can be used as a base. As the fat content of the milk could cause problems it is better to remove the cream first. The cream should be allowed to rise to the surface as quickly as possible before skimming. It can also be removed with a hand creamer.

Boil the (skimmed) milk for a period of 20 - 30 minutes in a closed saucepan. Transfer the boiled milk to a disinfected glass (use only glass!) jar which can be properly closed. Normal clay pottery is porous and therefore more difficult to clean, becoming a source of bacterial infection. Let the milk cool off to the proper inoculation temperature. This temperature can be found in the directions for use on the package of the starter culture.

5.4 Activation stage and inoculating the culture

For the production of the first starter culture you must use a powder. Add a little cold, boiled water to the powder and mix it to a smooth paste (everything coming into contact with the starter paste should be boiled first). Add a little more cold, boiled milk and set aside for about 2 hours. During this period the dried bacteria will be activated. Add the mixture to the milk for inoculation. This milk should be at the proper temperature as indicated in the directions for using the powder. There is always a possibility of contamination during inoculation of the cultured milk. Dry starters are usually weak and should therefore be grafted several times before becoming active (see Figure 4).

5.5 Maturing stage

Maturing starts the moment the starter culture paste has been properly mixed into the milk. A constant and correct temperature (as stated on the package) must be maintained. There are a number of ways to keep the culture at the desired temperature. It can be poured into a sterilized thermos flask while warm, or a haybox can be used to insulate a pot

containing the souring milk. Covering the saucepan with a blanket or placing the pot under the bed covers will also help to keep the temperature constant. Once the culture has matured (about 16-24 hours), it can be used to make sour milk products and cheese.

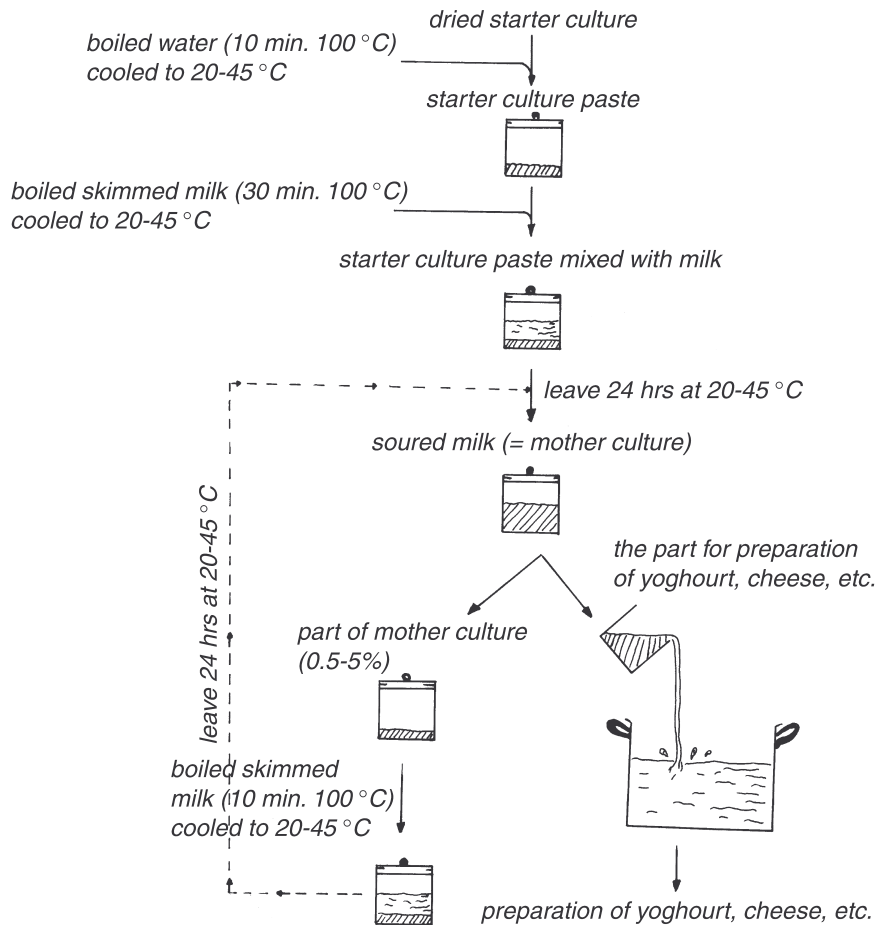


Figure 4: Maintaining the culture.

5.6 How to maintain the culture

Part of the culture will be used to inoculate fresh milk. The addition of 0.5% culture to the milk should be adequate, but may vary from 5 to 50 ml per litre depending on the temperature. You will have to find the proper quality by trial and error. Maintenance of the culture involves the daily transfer of existing culture to freshly boiled and cooled milk (use skimmed milk, if possible). If a refrigerator is available, inoculation can be done on a weekly basis. Keep the mother culture properly refrigerated.

The mother or starter culture must be transferred regularly, otherwise it will become too weak and useless.

5.7 Storage of the culture

If the rest of the culture is not used immediately, it can be kept for one week at most in a cool place (e.g. refrigerator). The culture can also be frozen in a small, clean, preferably glass pot or several pots. Do not fill the pots more than half way. Take them out of the freezer only when necessary and give them some time to defrost.

5.8 Activity of the culture

After the culture has been frozen and then thawed it may curdle. Nonetheless, it can be used to inoculate fresh milk as the culture is still active. After repeated use, the culture may become less active or its quality may decline because it may not have the desirable fresh, sour flavour any more. If it appears that the activity of the culture is declining after a time, a fresh powder starter should be used. A general guideline is to discard the culture when it takes longer than six hours to make yoghurt at 40-45°C, or 12 hours for milk to become sour after the addition of the culture to the milk.

Instead of using milk, one can use milk-powder. Clean, well boiled water is absolutely essential. Instead of a culture, a portion of the product (yoghurt, sour milk or buttermilk) can be used if the product

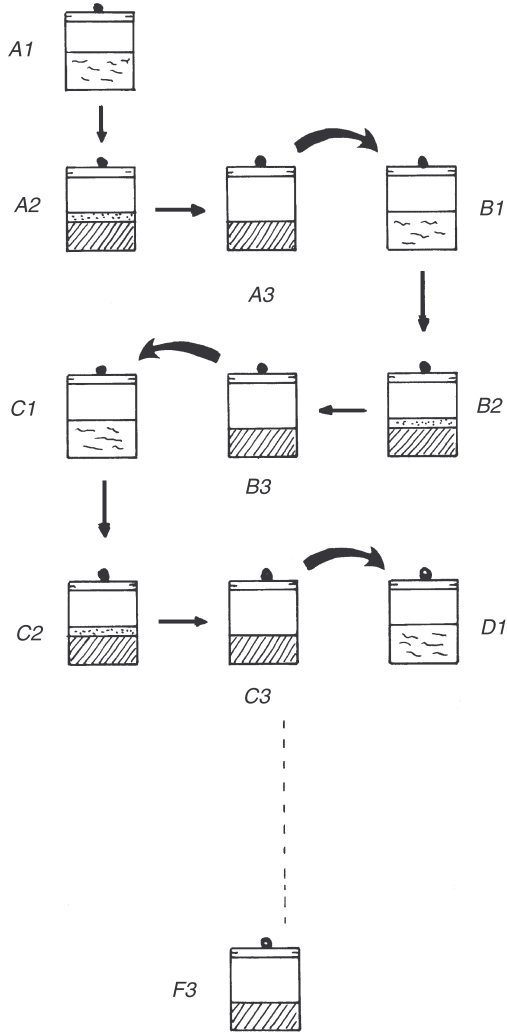
has been made shortly before, but this may lead to failure after a rather short time. The safest but also most expensive method is to use a new starter each time, certainly when soured milk products are made irregularly (i.e. not every month). This will save the effort of daily inoculation of a new culture.

5.9 Preparing your own culture

If starters cannot be obtained easily, it is possible to cultivate simple lactic acid starters from raw milk. Store raw milk at ambient temperature until it has developed sufficient acid to curdle. For instance: leave 1 litre of fresh, raw milk for 24 hours at 20-30°C. A second quantity of milk is then boiled for at least 5 minutes and cooled to the temperature at which the milk is usually fermented in the production process. The top layer of the available sour milk is skimmed off with a ladle (to remove aerobic micro-organisms) and thrown away. Add a small quantity of the soured milk (called inoculum) to the boiled milk (about 2 - 5%) and mix the milk and inoculum thoroughly by stirring. After 24 hours of incubation at ambient temperature, a fresh quantity of boiled milk is inoculated with a small quantity of the second batch of sour milk. The entire procedure is shown in Figure 5.

This procedure is repeated daily for about one week using disinfected equipment. Fermentation of the milk should take place in a bottle which must be closed with a disinfected stopper or in a well closed, airtight pot. It is essential that all the utensils and tools used (pots, spoons etc.) are clean and disinfected. The equipment can be disinfected by immersing spoons, ladles, bottles and stoppers in boiling water for at least 10 minutes.

After this period of cultivation the sour milk can be used as a starter. The amount of culture used to inoculate a new batch should be adjusted in such a way that the coagulated sour milk has a pleasant acid flavour at the time it is used.



- A1 : 1 litre unheated milk.
 A2, B2, C2: Milk gets sour after 24 hours at ambient temperature.
 A3, B3, C3: Remove cream from the soured milk.
 B1, C1, D1: Boil a quantity of milk and cool to ambient temperature in a clean jar. Add a small quantity from soured milk A3 (B3, C3 respectively).
 F3 : The starter culture, obtained after repeating the procedure until the 7th day.

Figure 5: Preparation of a starter culture.

Problems with the fermentation can have the following causes:

- The utensils were not clean enough when used.
- The cleaning agents were not rinsed off properly; these can slow down fermentation.
- Hydrogen peroxide has been added to the milk; this slows down fermentation.

Remarks

- When bubbles are formed or when there is insufficient souring, fermentation can take place at a slightly higher temperature. Raising the temperature by 2°C is usually enough but the temperature must not be allowed to rise above 37°C.
- If the product is too sour, fermentation must take place at a slightly lower temperature or the percentage of culture used can be lowered slightly.
- If the product is not sour enough, the percentage of culture added can be raised slightly, to a maximum of 5%.
- If glass jars are used, fermentation must take place in the dark.

6 Recipes

Every recipe in this chapter starts with a list of the ingredients and equipment needed. The actual preparation is then described. Success depends on a lot of factors, so do not give up if you do not end up with the desired results the first time. Experimentation is necessary and you will probably have to adapt the recipes.

Several preservation techniques (cooling, heating, drying, souring, salting etc.) are relevant to most recipes. Different types of milk can be used, which give different results. Take great care when disinfecting all pans, dishes and utensils (see Chapter 3).

Figure 6 shows all the different dairy products that can be made from milk, milk-powder, skimmed milk and buttermilk.

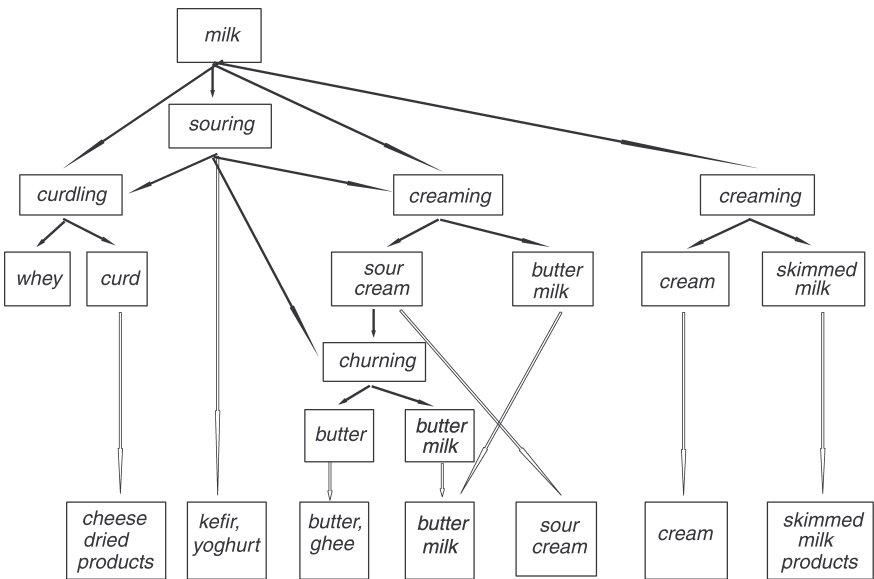
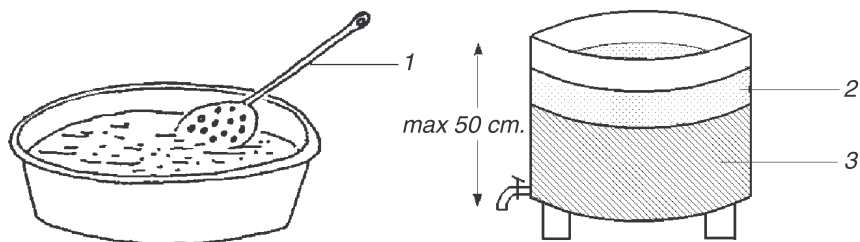


Figure 6: The preparation of dairy products.

6.1 Cream

You will need: raw milk and a heat source.



Allowing the cream to rise and skimming it off with a skimmer.

Allow the cream to rise and drain the skimmed milk through a tap.

Figure 7: Two methods for separating cream from milk. 1: skimmer; 2: cream; 3: skimmed milk

Method A

Materials: a dish, a spoon or saucer or skimmer, a container and a cool dust-free place (this method is only applicable to cow's milk).

After leaving milk to stand for about 24 hours at as low a temperature as possible (4-10°C), the cream can be skimmed off. Use a spoon, saucer or skimmer. A skimmer (creamier) works better as it lets the excess liquid drain through the holes (Figure 7).

This method makes use of the fact that cream rises and stays on the surface of the milk. It contains most of the milk fat. Only cow's milk readily produces cream this way, other kinds of milk need a hand creamer (centrifuge) to separate the cream from the milk.

Method B

Materials: a hand creamer (centrifuge), 2 big bowls.

Heat the milk slightly to a little over 40°C and pour it into a pan or creamer. It is important to turn the handle at a constant speed. The faster you turn the handle, the more fat the cream will contain. In this way you can more or less determine the cream's fat content. After separating the cream from the milk, pasteurise both cream and milk.

The use of a creamer produces more cream and leaves the skimmed milk with less fat. A disadvantage is that the creamer has to be cleaned and disinfected thoroughly (including the cylinders) which takes much time.

A hand creamer is a complete tool. Never buy a second-hand creamer before having checked that it works well. It might lack some irreplaceable parts or may be damaged. Always check whether the creamer is suitable for a particular type of milk (the size of the draining tube for cow's milk and goat's milk is different).

The cream can be kept for a few days if it has been pasteurized. It can also be used for the preparation of various recipes. Cream can also be used to make butter. The skimmed milk that is left after the cream has been removed still contains a lot of nutrients (protein, fat, milk sugars etc.) and can be used for consumption or the production of soured milk or cheese.

6.2 Sour cream

Method A

You will need unboiled raw milk, a heat source, a dish, a spoon or saucer or skimmer, a container and a cool dust-free place.

Cool the (cow's) milk to about 18°C. Let the milk sour in 24 hours and separate the sour cream from the buttermilk. After separation, both must be pasteurized.

Method B

You will need fresh cream, a saucepan, a thermometer, a sterilized metal or wooden spoon and a starter culture or buttermilk.

Cool the cream after pasteurization to 18°C. Add 1/2 decilitre (equal to 3 tablespoons) of sour buttermilk or a starter culture to one litre of cream while stirring constantly. Let the mixture become sour at a temperature between 16 and 18°C, stirring it once after a number of hours to allow it to mature evenly. After 24 hours the cream should be sufficiently sour and ready for consumption.

6.3 Butter

You will need: (sour) cream or sour milk, a heat source, a pan, a thermometer, a large container with cold water, sour buttermilk or a starter, a container for churning, a skimmer (if available), a sieve and cheese cloth or a container with a tap, a bowl, a tray for kneading, wooden spoons, fine salt if available, packing material (e.g. greaseproof paper) or a jar and clean water.

Butter is made by churning one of the following products: cream, sour milk, or sour cream.

If you do not have enough milk from which to skim off the cream, it can be soured and churned. Butter made from sour cream is usually tastier and more tenable than that made of soured milk. It is better to churn sour cream instead of sour milk, especially when a hand creamer has been used. This increases the quantity of butter.

It is only possible to manufacture sweet cream butter if the production and handling of milk, cream and butter are exceptionally hygienic. If you use pasteurized sour milk or pasteurized sour cream, you can start with the churning.

Heating and souring

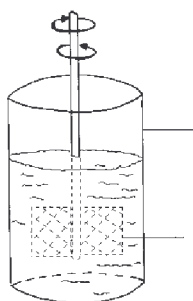
Heat the milk or cream during 15 seconds to a temperature of 85°C. Let it cool down to 18°C as quickly as possible (use a thermometer) using cold running water. Add 50 ml (about 3 tablespoons) of sour buttermilk or starter to one litre of milk or cream and stir thoroughly. Replace the cold water regularly if necessary. After about 24 hours the mixture will become thick and sour enough, ready to be churned.

Churning

During churning the (sour) cream or sour milk will be mixed. This process causes fat particles to coagulate, producing butter and buttermilk. The simplest way to make butter from small quantities of milk is by using a bottle that can be sealed (a disadvantage is the difficulty of removing the butter from the bottle) or a simple bowl with beaters.

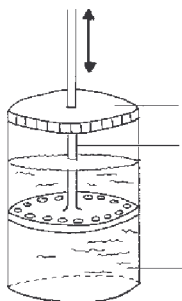
If large quantities of milk or cream are available, you should consider acquiring a real churn. There are several types available (see Figure

8). The churn tub is a simple method which is often used in the tropics. A cheap and practical domestic churn is a glass pot with a paddle attached to a screw top. The paddle can be turned manually. This churn is difficult to clean, though. It is best to rinse it with water before use, in order to prevent the butter from sticking to the sides. The churn should not be filled more than half way with soured milk or sour cream. Churn with a regular up and down or sideways movement. Stop churning when the butter particles reach the size of rice grains or peas and the buttermilk looks rather watery. If, after 30 minutes, no grains have yet been formed, you can change the temperature by adding a little clean cold or warm water (see the remarks at the end of this chapter). The amount of added water should never be more than 25% of the total amount of churned cream or milk.

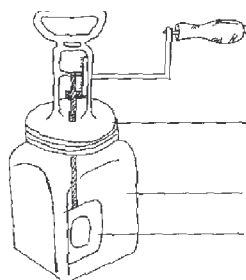


Bowl with whippers.

1: bowl with cream
2: rotating whippers



3: lid with hole
4: plunger to move up
and down
5: churn tub



Glass household churn.

6: screw lid
7: glass jar
8: paddle

Figure 8: Three examples of simple churns.

After churning, remove the butter particles from the top and sides using cold clean water. The water with the butter particles will float on top of the buttermilk, because it is lighter than buttermilk. This makes it easier to separate the two products by pouring off the buttermilk

through a coarse sieve. Never add too much water, otherwise the buttermilk will become too watery.

Washing

Washing the butter can be done in two ways:

- 1 Fill the churn $\frac{2}{5}$ full with clean, cold water. Wash the butter by churning it for about 10 minutes. This can be repeated if necessary. The idea is to remove the remaining buttermilk from the butter particles. It is important to remove as much as possible in order to produce butter that can be kept for a longer period. After washing, the butter particles can be skimmed off or the buttermilk can be drained.
- 2 If small quantities are available, the butter particles can be washed using a sieve. Put the sieve on top of a bowl and pour the mixture through it. Remove the remaining buttermilk with cold water while turning the butter with a spoon. Make sure that during churning the butter does not become one big lump, otherwise it will be difficult to wash.

Salting

The butter can be slightly salted (according to taste) by kneading in about 10 grams of salt to each kilogram of butter. Mix the butter again the next day in order to allow the salt grains to dissolve.

Kneading

Kneading the butter is important in order to get a nice, smooth product. It helps to distribute the moisture and improves quality and shelf-life.

Use a clean, well rinsed kneading board. Knead the butter with the back of two wooden spoons until no more drops of water are seen and the butter has a nice, smooth surface. Remove the water during this process. Instead of a wooden spoon, a wet roller or bottle can be used as well. If nothing is available, just use clean hands to knead.

Storage

Butter should be stored in a dark cool place. Put it in a pot or wrap it up in grease-proof paper or aluminium foil. After a while the surface of the butter will be covered with fungal growth. Mould formation can be partially prevented by sprinkling salt on the surface. Butter can also be frozen. However, after defrosting the butter will soon become rancid. It is therefore a good idea to divide the butter in smaller portions before freezing. Salted butter is not suitable for freezing.

Remarks

- 1 If milk has gone sour without the use of the above-mentioned recipe yet tastes and smells fresh, it can still be churned.
- 2 Churning can take from 15 to 60 minutes. There are a number of factors which may influence the time needed, for instance:
 - Type of animal the milk came from.
 - Food eaten by the animal.
 - Fat content of the cream.
 - Temperature during churning. If the room is cold the fat globules do not easily stick together and churning will take longer. If the room is too hot, churning will go quickly and the butter becomes too soft, making kneading almost impossible. A good churning temperature is 15-20°C.
- 3 The above recipe is specifically meant for cow's and goat's milk. When churning other types of milk, start with cream from a hand creamer and not simply with milk.
- 4 Butter has a limited shelf life. It can become mouldy or rancid. An unpleasant cheese-like flavour may develop due to the deterioration of its protein. An alternative is Ghee, which does not spoil as quickly as butter. Ghee is produced by removing the last water remnants from butter by heating the butter and letting the water evaporate, or by melting butter and draining the water which separates from the fat.

6.4 Buttermilk

Buttermilk is a by-product of the butter making process. The taste can be more or less sour depending on the sourness of the cream or the milk which is used for butter making, or the degree to which it sours after churning. It is also possible to make soured buttermilk using milk or skimmed milk.

You will need: raw or skimmed milk, a heat source, a wooden spoon which has been boiled, soured buttermilk or a starter, a saucepan with a thick bottom, thermometer, a cooling facility (a big pan with cold water, a cellar or a refrigerator).

Heat the milk or skimmed milk to boiling point, stirring all the time. Cool it down to 18-20°C, for instance in a large pan with cold water. Add 50 ml of sour buttermilk or a starter to each litre of milk or skimmed milk. Leave for 18-24 hours at 18-20°C; if the surrounding temperature is higher, a large pan with cold water or a cellar can be used. After this, cool it down in a large pan with cold water or in a refrigerator, so as to prevent further souring.

6.5 Ghee

You will need: butter or cream, a heat source, a pan, a skimmer or metal spoon.

Heat the butter or cream until water and fat form separate layers; the fat will float on top. There are two ways to remove the water:

- It can be removed by further heating (for butter only). The water present will evaporate.
- It is possible to remove the layer of fat with a spoon (for butter and cream). This fat should then be heated again. The scum which will form has to be skimmed off regularly, preferably with a skimmer. The colour of ghee can vary from almost white to dark brown. A rancid flavour is acceptable, but if it tastes burnt it should be discarded.

6.6 Koa or Khoa

You will need: (unboiled) whole or skimmed milk, a heat source, a shallow clean wide iron pan with a thick flat bottom, a flat clean metal utensil to stir with (a flat pancake knife, for instance).

Bring the milk to the boil, stirring constantly. After a while the milk will thicken. Take great care to scrape the sides of the pan during stirring. Once the milk has reached a dough-like consistency and stirring does not prevent the mass from sticking to the side of the pan, you can remove it from the heat source. At this point the water content should have been reduced to about 40% of what it was. Take the lump of koa out of the pan, put it on a cold surface and flatten it. After cooling, the koa will be firm and can be cut into squares. It will have a sweet, nutty flavour. Koa can be kept only for about 2 - 5 days because of possible reinfection.

The preparation of koa requires much time (a few hours) and fuel, on top of which 1 litre of milk produces only 0.4 litres of koa. Remember that vitamins are broken down (vitamin B6 and B12) during preparation.

6.7 Rabi

You will need: (unboiled) milk, a heat source, a wide shallow iron pan with a thick bottom, a flat metal scoop, sugar, scales.

Add sugar to the milk (maximum 300 g. per litre of milk) and follow the same procedure as for koa. Lumps of sugar will often be found in the end product.

6.8 Yoghurt

Yoghurt is produced when milk is soured by certain bacteria. The milk should be heated to 85°C to make sure useful bacteria grow and harmful, unwanted bacteria in the milk are killed. After the milk has been soured, the yoghurt bacteria are still viable. That is why a little of

the old yoghurt can be used to make fresh yoghurt by adding it to fresh milk.

Basic recipe for yoghurt

You will need: raw milk, a heat source, a saucepan, cooling facility (e.g. a large pan with cold water), a wooden spoon (boiled), thermometer, yoghurt culture, starter for yoghurt or some fresh yoghurt, thermos flask or haybox, a cool place (refrigerator or cellar). Stir the milk, heat it to 85°C or its boiling point and keep it at this temperature for 3 minutes. Cool the milk as quickly as possible to 45°C (e.g. in a second saucepan with cold water). Add 50 ml. (3 tablespoons) of yoghurt to each litre of milk; the yoghurt should not be more than one day old. Instead of yoghurt you can use a yoghurt culture. Stir the milk thoroughly and leave it to sour. The time required for the milk to sour depends on the temperature. To give you an idea:

- at 40 - 45°C it takes 3 to 6 hours
- at 35 - 37°C it takes 15 to 20 hours
- at 30°C it takes about 24 hours

The ideal temperature to make pleasant tasting yoghurt is 45°C.

It is not possible to produce yoghurt at temperatures below 30°C or above 50°C. The correct temperature can be maintained using a haybox. Yoghurt is ready for consumption once the incubation period is finished. If cooled, yoghurt can be kept for one week.

Using a thermos flask

Heat the milk to 85°C, then cool it to 45°C. Pour 90% of the milk into a thermos flask which has been rinsed with hot water. Mix a tablespoon of yoghurt made the day before or a yoghurt culture with the rest of the milk and add this to the thermos flask. Close the flask well, shake it and leave to stand for 3 - 6 hours. Remove the yoghurt from the thermos flask and store in a cool place. Yoghurt made of sheep's milk is very thick and not suitable to be made in a thermos flask.

Yoghurt made from milk-powder

Make milk from milk-powder according to the instructions, but add 10 to 15% extra milk-powder. Dissolve the milk-powder in boiling water and let it cool off to 45°C. Stir in 3 tablespoons of fresh yoghurt or a yoghurt culture per litre of milk. Cover the saucepan and put it in a warm, insulated place (e.g. a haybox). After 3 - 6 hours the yoghurt should be ready for consumption.

Remarks

- It is best to use fresh milk to make yoghurt. Milk-powder can also be used. Sterilized milk gives a thinner yoghurt than pasteurized milk.
- After incubation, cooling is desirable, preferably below 10°C, so that souring is stopped (the taste remains good) and the bacteria remain more viable, while the yoghurt can be used to inoculate milk again. If it is not possible to cool below 10°C, some yoghurt should be added to fresh milk immediately after yoghurt making (when it is still sour enough). Otherwise the bacteria will die because the yoghurt becomes too sour.
- Make sure the milk sours as quickly as possible, preferably at 40 - 50°C rather than 30°C. Harmful bacteria have less opportunity to develop if the incubation period is shorter.
- A thicker yoghurt can be produced by adding 2 to 3 tablespoons of milk-powder to each litre of milk before heating it to 85°C.
- It is not advisable to use fruit yoghurt from a shop as a culture because it contains a lot of additives. Plain yoghurt from a shop can be used if it is not too old. Sterilized yoghurt is not suitable either because the bacteria have been killed.
- When using yoghurt from a carton or a pot as a starter, first remove the top layer and take the yoghurt from the centre to make fresh yoghurt. This is because the bacteria in the middle are probably the most diverse and active.
- Stir as little as possible to avoid any extra risk of incorporating undesirable bacteria.

6.9 Kefir

Kefir, like yoghurt, is a milk product first discovered by the nomadic tribes which live in the cold areas of the Caucasus. When making kefir, acid, gas and a little alcohol are produced. It also has a special aroma which is different from that of yoghurt. Kefir is made by using a 'yoghurt plant', which is actually a misleading name as it is not a plant. The 'yoghurt plant' is in fact a cauliflower-like lump of micro-organisms consisting of yeasts and bacteria. The yeasts produce alcohol and gas, while the bacteria convert the milk sugar into lactic acid. You may be able to obtain a piece of kefir from someone who regularly makes kefir. If not, get some dried kefir granules at the local market.

You will need: raw milk, a saucepan, a heat source, a thermometer, a clean pan, a glass bottle with wide neck, a bottle which can be closed tightly, kefir granules or a 'yoghurt plant', a sieve, cooling facility (a pan with cold water or a cellar), clean water, a tea cloth, a cool place.

Boil the milk and put it into a bottle which has first been thoroughly cleaned with boiling water and rinsed with hot water. Do not fill the bottle completely; let the milk cool down to 20°C (use a thermometer). Add one tablespoon of soaked kefir granules to each half litre of milk in the bottle and cover it loosely so that the gas produced can escape. You can use a yoghurt plant instead of the soaked granules. Keep the bottle at a temperature of 16 to 18°C. After 24 hours the milk will have become a little thicker, forming some froth: this is kefir. Sieve the kefir and use the granules which remain in the sieve to make fresh kefir again. The kefir is now ready for consumption.

Ripening of the kefir

The kefir can be left to ripen, during which further fermentation takes place. This is essential for its characteristic qualities. Pour the milk into a well cleaned bottle which can be closed or a bottle with a clip fastening and do not fill for more than 3/4 because gas forms during ripening.

Leave the bottle at about 15°C, but do not store it for more than 3 days. Towards the end of the ripening process the whey separates and can be incorporated again by stirring or turning the bottle. The end product is a thick, creamy, frothy drink with a sour taste and smell. If the kefir is left to ripen for more than 3 days, the milk may curdle and the drink becomes too sour. The temperature and the time are important as they determine the flavour. The kefir can be kept in a refrigerator or a cellar for a few days.

Storage of the kefir plant

If kefir production is stopped for some time, the kefir plant can be dried as follows: Put it into a sieve and rinse well with clean water until all remaining milk is removed. Place it on a clean cloth and leave to dry in a clean place, but not in the sun, until the granules have shrivelled up. The granules can be kept in a closed bottle in a cool place for 12 to 18 months. The rinsed granules can also be kept in a freezer. Kefir granules can also be kept in a pot with water at 4°C, but they become inactive after 8 to 10 days.

Remarks

- There is a greater chance of failure with kefir than with yoghurt. The end product may not only taste bad, it can also be unhealthy. In order to produce good kefir, the appropriate hygiene should be applied. Care should also be taken not to work at too high temperatures.
- The storage life of kefir is the same as for yoghurt and buttermilk: its quality will rapidly decline if it is stored too long. At 5°C, soured products can be kept for about ten days; at 10°C this is three days, and 20°C is too high.
- Kefir may be too sour or too yeasty (due to an incorrect balance between the activity of the bacteria and yeasts). A fishy or ammonia-like taste can be the result of a breakdown of proteins by undesirable bacteria which enter due to insufficient hygiene.

7 Cheese

Cheese is a product that has been known for centuries. Virtually all the nutrients present in milk are concentrated in cheese (see Figure 9).

Cheese production in the tropics is typified by specific problems which have as effect that production processes and end products differ from those in Western Europe.

- Outside the temperate zones, high temperatures and very high air humidity must be taken into consideration. Both these factors are unfavourable for cheese making, in particular for the ripening of cheese.
- Milk is often available in small quantities, while its quality may not be up to standard. In particular, its cleanliness and composition may leave much to be desired.
- Hard and half-hard cheeses require good quality milk and hygienic preparation. Moderate temperatures are needed for good ripening and storage of such cheeses. Most cheeses made on “farms” in warm and hot climates are therefore soft cheeses.
- In many tropical and subtropical countries, ripened cheese is not very popular. Most consumers are not used to the distinct flavour and smell of such cheese.

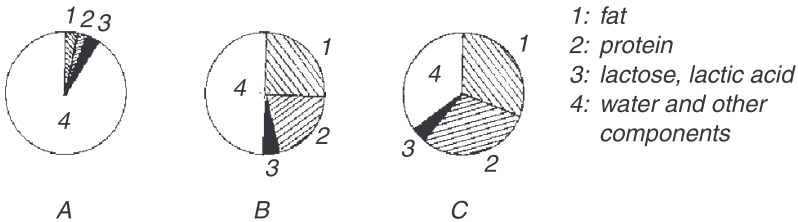


Figure 9: Composition of milk (A), fresh cheese (B) and hard cheese (C).

The shelf life of cheese can vary from several days to a few months, depending on its preparation. Soft, and therefore fresh, cheese can be stored for only a very short time; it must be consumed immediately or within a few days. The keeping qualities of such cheese can be improved by salting. Soft cheese which has been curdled using only an acid cannot be ripened, and should be eaten immediately. Half-hard cheese can be kept well for 3-4 months. Cheese which is able to continue ripening should not be kept in a refrigerator, but in a cellar or cool place at 10-15°C. Where applicable, information and instructions will be given in the recipes on keeping qualities and ways of storing products.

Five basic operations can be distinguished in cheese making and will be discussed in this chapter. These are:

- The treatment and quality of the milk used to make cheese.
- The coagulation (curdling) of the milk using an acid or enzymes.
- The separation of the curds from the whey.
- The treatment of the curds.
- The ripening of the cheese.

7.1 Utensils for making cheese

When making cheese, you will not always need all the utensils described below. Decide beforehand which you will use, and make sure that they are clean and disinfected or rinsed with boiling water. It is preferable to use utensils made of stainless steel or glass.

The utensils used during cheese making are (see Figure 10 and 11):

- 1 A pencil thermometer with a range of 20-80°C.
- 2 A measuring cup.
- 3 A bucket for milk. This will be used to curdle the milk in.
- 4 Cheese moulds, which can be made in various ways.
 - Tubes made of non-rusting materials or plastic (do not use plastic tubing used in construction as it can release poisonous substances). Cut the tubes lengthwise and drill holes from the inside out. The cheese acquires a good form and can be easily removed.

➤ Cans in which holes have been made from the inside out. They rust quickly and thus can be used for only a short time.

➤ Cheese moulds made of wood.

Cheese is never(!) placed directly in a mould. Instead, a clean cloth is first placed in the mould and it is then filled with curds. The cheesecloth is then folded closed.

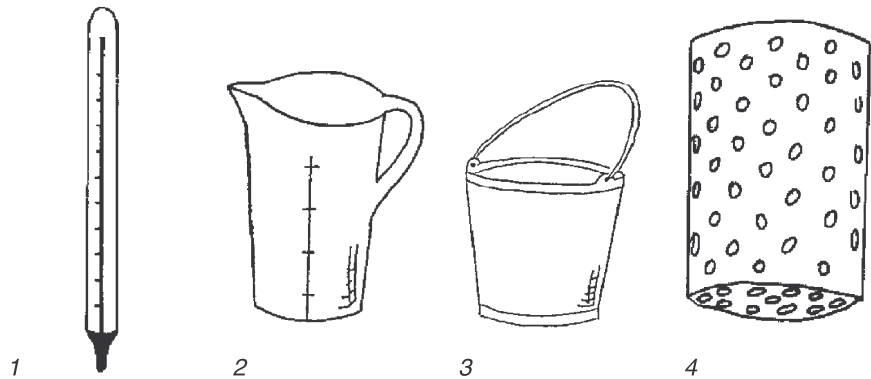
5 Cheesecloth. This is a cloth of thin cotton about 60 x 60 cm.

6 Cutlery and other tools such as:

➤ Spoons to measure rennet or a souring agent.

➤ A knife to cut curdled milk.

➤ A skimmer to scoop curds out of whey, or a colander.



1: A thermometer.

2: A measuring cup.

3: A bucket.

4: Cheese mould: tin with perforated sides and bottom.

Figure 10: Utensils for cheese making.

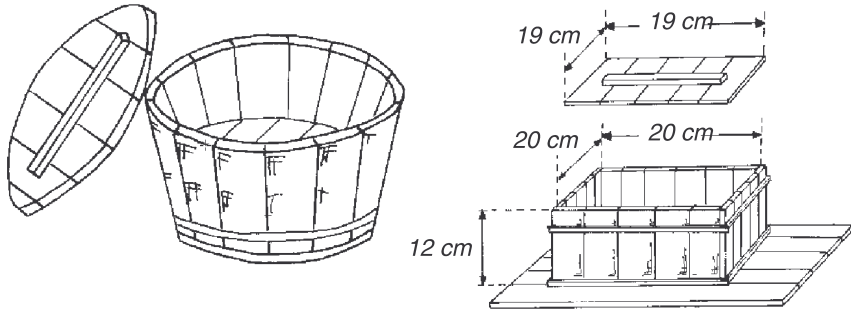


Figure 11: Cheese moulds made of wood.

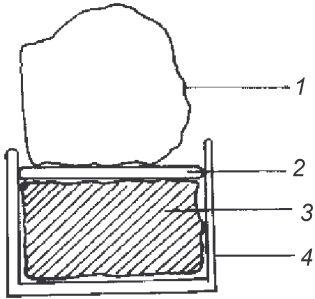
To make half-hard cheese you will also need a cheese press (see figure 12). Buy this second-hand if possible, improvise, or make your own simple press, paying special attention to the following:

- the materials used must not be poisonous.
- It must be possible to easily clean and disinfect the materials.
- It must be possible to build up sufficient pressure (0.1 to 0.4 kg/cm² or 2-5x the weight of the cheese).
- The pressure must be controllable so that it can be gradually increased.

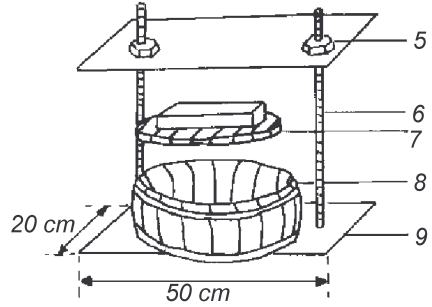
1 Simple cheese press.

2 Cheese press made of two pieces of metal of 50 x 20 x 0.5 cm for the top and bottom of the press, 2 large bolts 30 cm long and 0.75 cm in diameter threaded along their entire length and 2 nuts. The bolts are welded to the metal bottom plate, the top plate is held in place by the two nuts. Bottom and top plates can be made larger. This press can be made by anyone who knows how to weld a bit.

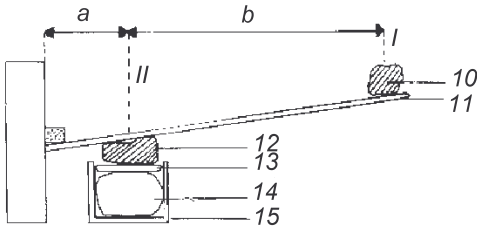
3 Improvised cheese press based on the principle of the lever. For this is needed: a long strong plank or pole, a small wooden plank, two or more rocks, a wooden platform and a tree or wall. Pressure can easily be increased by placing the stone closer to the end of the plank. If $a:b = 1:3$ then stone 2 puts 4 times as much pressure as stone 1. Therefore 10 kg at point I gives 40 kg at point II (see Figure 12).



A simple cheese press.



Cheese press made of two pieces of metal for the top and bottom of the press.



Improvised cheese press based on the principle of the lever.

- 1: stone
- 2: lid
- 3: cheese
- 4: cheese mould
- 5: nut
- 6: bolt
- 7: lid
- 8: cheese mould
- 9: metal plate
- 10: stone 1
- 11: board
- 12: stone 2
- 13: lid
- 14: cheese
- 15: mould

Figure 12: Example of simple cheese presses.

7.2 The quality of the milk used to make cheese

Cheese making begins with milking. The quality of the milk used greatly influences the smell, taste and keeping qualities of cheese. The composition of milk can vary greatly. Just before a cow is set dry (the period in which a cow is not milked) and just after calving (the birth of a calf), the cow's milk has a different taste and composition.

Milk from a cow with an udder infection is not suitable for human consumption, and therefore cannot be used for making cheese.

Apart from the usual measures taken for hygiene during milking, attention must be paid to the following points:

- Disinfect utensils.
- After disinfection, no cleaning agent must be left in or on equipment. Cleaning agents slow the development of the souring agent.
- The space in which cheese is prepared must be kept properly clean. Bread or fruit sometimes contain yeasts which can reduce the quality of cheese.
- The milk used for cheese making should preferably be pasteurised (15 seconds at 72°C or 30 minutes at 63°C). Intense heating is not desirable because:
 - 1 it reduces the curdling of milk; more rennet or calcium chloride (CaCl_2) is then needed.
 - 2 when ripening, the cheese will become bitter.
- For the above reasons, milk-powder, which is strongly heated during its production, is less suitable for cheese preparation. Low-heat milk-powder can only be used for the production of fresh cheese.
- Sour milk neutralised with sodium bicarbonate will not curdle well.

7.3 Coagulation of the milk

The principle of cheese preparation is based on the coagulation of the protein in milk, during which about 90% of the milk fat is encapsulated. The coagulated mass is called curd, the remaining liquid

is called whey. Curds consist mainly of milk fat and milk proteins, whey mainly contains milk sugar (lactose). There are two ways to cause milk to coagulate: using an acid or using a rennet.

Acid coagulation

This is mainly used to make fresh cheese. The acid can come from bacteria in the souring agent or from an acid added to the milk. When using a culture, pasteurised milk is inoculated. Inoculating agents can be a specific cheese acidifying agent, whey or buttermilk. Curdling time depends on the amount of inoculating agent added (0.1 - 5% of the milk used to make cheese), temperature (20-35°C) and the starter culture used. It takes 2-16 hours. When the curds can be cut leaving a clear, smooth break, the curdling is finished.

When using an added acid, you can use pure vinegar acid, lactic acid, citric acid or any other harmless organic acid. Sometimes a natural acid such as lemon juice is added. The acid can be added drop by drop to warm milk (about 80-90°C, just after boiling). Milk curdles quicker at a high temperature.

Rennet

Rennet used in the preparation of cheese can be of animal, vegetable or microbial origin. The rennet in cheese has two functions:

- To coagulate the milk.
- During ripening, rennet causes milk protein to break down, giving a sharp taste to cheese.

The concentration of the rennet is written on the package. The amount of rennet to be added depends on the strength of the rennet and on the kind of cheese you are going to make. When making soft cheese, no rennet is needed; if rennet is added, only a little is needed (0.1 ml of rennet to 10 litres of milk). For hard cheeses, about 1.5 ml of rennet is added to 10 litres of milk (assuming the rennet concentration is 1:10,000). An acid is almost always added before or while adding rennet.

A number of factors which influence curdling are:

- The amount of rennet or acid added.
- The curdling temperature; when using rennet a small rise in temperature (for example from 30°C to 33°C) can significantly reduce curdling time.
- The intensity of the pasteurisation; curdling is reduced when milk has been strongly heated. This effect can be neutralised by adding a small amount of CaCl_2 (for example 7 grams of CaCl_2 per 100 litres of milk).
- The fat percentage of the milk; a high fat percentage means more fat must be encapsulated and curdling goes slower.
- The kind of milk; milk from goats and buffaloes curdles quicker than cow's milk.

In the following figure, four methods of curdling milk are shown.

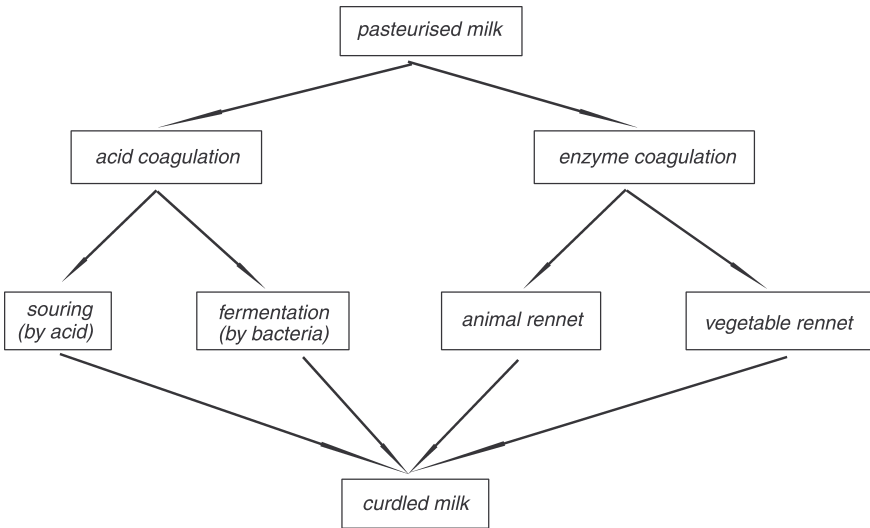


Figure 13: Four methods of curdling milk.

7.4 Separating curd and whey

Three methods can be followed to separate curds from whey:

- Hanging the curd/whey mixture up in a clean cloth (see Figure 14).
- Putting the curd/whey mixture in cheese moulds (or in cylindrical forms with perforated sides).
- First cutting the curd/whey mixture, putting the curds in the cheese moulds and then pressing the cheese.

When making fresh cheese, the first or second method is usually used. As the whey drains through the cloth or mould, the volume of the curds will reduce to $\frac{1}{3}$ of what it was. When making ripened cheese, the last method has to be used to remove sufficient whey from the curds. The effect of cutting and pressing is described below.



Figure 14: Letting soft cheese drain.

Treatment of the curd

The amount of whey in the curd has a great influence on the taste and keeping qualities of cheese. Whey contains milk sugar (lactose) which can be turned into lactic acid by lactic acid bacteria (present in the souring agent added). If a lot of whey is removed from the curd, you get:

- Cheese with little moisture, therefore a dry cheese.
- Cheese with little lactic acid (from the lactose), therefore not very sour.

If little whey is removed from the curd, you get:

- Cheese with a lot of moisture, therefore a “wet” cheese.
- Cheese with a sour taste.

Since the curd treatment of fresh cheese and ripened cheese is quite different, they will be discussed separately.

It is important that the curd does not cool down, and remains at about 30-36°C. The curd treatment can be started when, on cutting the curd mass, a clear cut is made. You can determine this by sticking a knife or some such thing in the curd and removing it again; a smooth clear cut must be made.

Curd treatment for fresh cheese

As a rule, to make fresh cheese little whey is removed. After curdling the milk, the curd/whey mass is hung in a cloth or placed in cheese moulds. After 24 hours, enough whey has leaked out and the curds are cooled down. The cheese is then ready for consumption. The separation of the whey can be stimulated by piling the cloths or cotton sacks on top of each other so that more whey is pressed out of the cheese.

Curd treatment for ripened cheese

After curdling milk, the coagulated mass is cut with a sharp knife into square cubes of about 1.5 cm. It is important that the cubes are all of approximately the same size, and that the cutting is done gently. After cutting, the curd/whey mixture is briefly left to stand (about 10 minutes) after which it is carefully stirred. After some time it can be stirred more vigorously. The whey is removed from the cheese tub and the curd is placed in the cheese moulds. The curd is then pressed (0.1 kg/cm²). After about 1 hour the pressure can be increased to 0.4 kg/cm². Other ways of determining the pressure are respectively 2x and 5x the curds' own weight.

After being pressed, the cheese is left lying for some time (4-20 hours) at 20-25°C. In that time the lactose present in the cheese is completely converted into lactic acid. The cheese can then be salted.

Salting the cheese

This can be done in 3 ways:

- 1 Stir the salt through the curd (30 grams of salt per kg. of curd). This reduces the effect of the souring agent, but potentially damaging micro-organisms are also halted at an early stage.
- 2 After pressing the cheese, rub it in with salt. Rub both sides in and then turn the cheese. This must be done every day for 3 days; in total 20 grams of salt is needed per kg. of cheese.
- 3 Place the cheese in brine of 200 grams of salt per litre of water at 14-18°C. During this pickling, the cheese absorbs salt and secretes lactic acid. The brine becomes sourer and improves in quality; it should therefore not be thrown away. Occasionally salt must be added to the brine; 20 grams of salt is removed from the brine by each kilogram of cheese. For a small cheese (less than 1 kg), pickling time is about 12 hours. During pickling, the cheese must be turned once.

After pressing and resting, the cheese is sometimes rinsed with warm water (40-50°C). This ensures that the cheese remains warm enough for the lactic acid bacteria to remain active, and it stimulates the formation of a good rind.

7.5 Ripening of the cheese

Various methods are known to ripen cheese. First a good but technically difficult way of ripening cheese will be discussed. Then various directions for making curds storable will be given.

After salting or pickling, cheese is ripened in a cool environment (12-20°C) with a high relative humidity (85%). The high relative humidity is achieved by, for example, spraying water on the ground of the ripening room. Cheese must be turned regularly, initially daily, later on once a week. If mould grows on the cheese, it can be removed with vinegar or sunflower oil.

The following treatments can be carried out on curds:

- You can salt curds, make little balls of it, and leave them to dry in the sun.
- Curds can be smoked over a fire.

- Curds can be boiled in brine.

The products which result are particularly suitable to be processed in other foods.

7.6 Cheese recipes

There are many variations to making cheese. To make a good product, it may be necessary to adjust the recipe. Therefore it is necessary to write down how the cheese is made. The list can include the following points:

- Date and surrounding temperature.
- Quality of the milk and pasteurisation temperature.
- Amount of milk.
- Amount of souring agent, acid or rennet added.
- Temperature at which souring agent, acid or rennet was added.
- Curdling time.
- Temperature at the end of coagulation.
- Pressure applied, length of time applied, etc. etc.

The following recipes should be seen as guidelines for making cheese. Instead of cow's milk, you can often use goat's, sheep or buffalo milk. Start by making easy kinds of cheese.

Fresh cheese

Fresh or unripened cheese has a high moisture content of about 75% and can be consumed directly after preparation. It is made by removing the whey from soured milk. The milk is usually curdled by souring. Sometimes a small amount of rennet is added; this is done to facilitate the draining of the whey. However, adding rennet is not essential.

Curd cheese

A well-known kind of fresh cheese is curd cheese, known in various countries by the following names: Frischkäse, fromage frais, Quarg, baker's cheese. You can make curd cheese by letting milk sour,

placing the thick sour milk in a bag or cloth, and letting it drain. Sometimes bags are placed on top of each other to increase the removal of whey. After draining, curd cheese has a crumbly structure. By stirring or using a blender you can make the product smooth again. There are various kinds of curd cheese in which moisture, fat and salt content and size of curd particles vary.

Fresh cheese, and therefore curd cheese, has a fresh sour taste. By adding cream, the taste can be made milder and richer. Curd cheese can be kept for only a short time and must be stored at cool temperatures. During storage, further whey separation occurs; this is the result of further souring of the product.

Full-cream curd cheese

Pasteurize the milk at 63°C and then cool it to 20°C. Add the following per 10 litres of milk:

- ½ litre of souring agent or fresh buttermilk, yoghurt can be added if desired.
- If available, 2 drops of rennet. It is advisable to dilute this small amount of rennet with several ml of water to improve its distribution through the milk.

After stirring well, leave the milk plus additives to stand for 24 hours at the same temperature. During those 24 hours, souring and some curdling will take place; the milk thickens. This thick mass is subsequently placed in a cotton or linen cloth (or bag) so that the moisture (whey) can drain through the cloth. The cloth is placed in a large colander or cheese mould beforehand so that the whey can thoroughly drain. After 24 hours, sufficient whey will have leaked out and the remaining curd can then be stirred vigorously, for example with a spoon or blender, until it becomes a homogenous mass. The curd cheese can now be consumed.

When kept in a refrigerator, curd cheese can be stored for 1-2 weeks.

Bag cheese

You will need a sieve, small basket or cheese mould and cheesecloth.

Let 10 litres of buttermilk drain through a cheesecloth until 1.5 litres of bag cheese (curd) remains. Place a cheesecloth in a sieve, small basket or cheese mould and press the curd firmly into it. Let the curd drain for several hours, then turn it. About 1.5 kg. of bag cheese has then been made, which contains no salt and hardly any fat. It can be kept for only a short time. Keep it cool (in a refrigerator).

Krut

You will need buttermilk, cheesecloth and salt.

This is a way to make cheese from any left-over milk. Add some buttermilk to the left-over milk and mix well. Boil the mixture until the milk curdles. Separate the curd from the whey by pouring it through a cheesecloth. The curd is then kneaded with 2-4% salt and dried in the sun.

Rasagollas

You will need raw milk, a fire, pan, spoon, lemon juice or sour whey, cheesecloth, bowl, knife and concentrated sugar water.

Rasagollas is a sweet dairy product originally from India. Traditionally they are sweet curd balls, but because of the way it is prepared here, the curd can only be cut into cubes and not formed into balls.

The milk is boiled with lemon juice (10 tablespoons or 150 ml per 10 litres of milk) or sour whey (1.5 litres per 10 litres) while stirring continuously. Sour whey is whey obtained from milk that has been soured using a souring agent. The curds are separated from the whey by pouring the mixture into a cheesecloth which has, for example, been placed over a bowl. The slightly elastic curd is cut into cubes with sides of about 2.5 cm. These are then boiled for about an hour in a sugar solution of 600 g. per litre of water (1 litre of sugar solution is needed for each kg. of curd). The cubes can be stored quite some time and are very sweet.

Feta

You will need sheep's, goat's or cow's milk, souring agent, rennet, kitchen salt, knife, cheese moulds, cheesecloths and cans or a container in which to store the cheese.

Feta is a sharp, salty cheese originally from Greece made of sheep's milk. You can also use a mixture of sheep's and goat's milk, but then the cheese will not have its typical white colour. Feta is kept in a solution of whey and brine.

Heat 10 litres of pasteurised milk mixed with 150 ml of souring agent or buttermilk to 30°C. After 2 hours, rennet is added; 2 ml of rennet per 10 litres of milk. After allowing it to coagulate for about one hour, the curd is cut into cubes of about 2.5 cm, after which it is carefully stirred for another 20 minutes.

The curd must be carefully transferred to the tubs covered with cheesecloth. This can be done either by scooping the curds directly out of the whey and placing them in the moulds lined with cheesecloth, or by letting the curds settle, pouring off the whey and only then putting the curds in the cheese moulds.

After a few hours the cheese must be turned. The curd mass is carefully removed from the cheesecloth and replaced upside down. After one day, the lumps of curd are cut into cubes of about 10 cm. Salting can be done by sprinkling the blocks several times with salt or by placing the blocks in brine for 24 hours.

If the cheese is kept for several days (at about 18°C), it must be turned regularly and washed with cold water at the end of the storage period. The cheese can be kept for some time by piling blocks of cheese closely on top of each other and covering them with brine.

The cheese should have a smooth and soft consistency.

Queso Blanco

Queso Blanco is made in many ways in Latin America. Typical for this cheese is that salt is added directly to the whey/curd mixture. The advantage of this is that slightly soured milk can be used to make Queso Blanco.

A much used method is the following:

To raw (unheated) soured milk which is at 32°C, or to 10 litres of pasteurised milk to which 50 ml of buttermilk or souring agent has been added, 1.5 ml of rennet is added. After 45 minutes the curds are cut and stirred. The whey/ curds mixture is left to stand for another 30 minutes at 30-36°C. The whey is poured off and the curds are compressed to remove more whey. 30-50 grams of salt are then added to the curds and again stirred vigorously (or loosened). The salted curds are transferred to cheese moulds after which the cheese is pressed. During the first hours the curds are occasionally turned. They are then pressed until the following day. To improve rind formation, warm whey at 50°C can be poured over the cheese while it is being pressed (after one hour). This warming during pressing also improves the structure of the cheese. Cheese made with rennet can be kept for 2 months at 10-15°C.

Note: The salt can also be dissolved in water before being added. 100 grams of salt dissolved in 50 ml of water must then be added for each 10 litres of milk.

A variation to this method is: adding acid.

The milk (raw milk, sometimes already soured) is heated to 70-80°C and curdled with vinegar until a precipitate is formed. To then partly neutralize the acid, sodium bicarbonate (double soda) is sometimes added. The whey is poured off. Further preparation is as above.

Fresh goat's cheese 1

You will need pasteurized goat's milk, a heat source, pan with lid, thermometer, buttermilk or souring agent, rennet, spoon, haybox or newspapers, cheesecloth, salt, cheese moulds, cool place and if available grease-proof paper, large pot, herbs and olive oil.

Warm the pasteurised goat's milk to 20°C and for each 10 litres of milk add half a litre of fresh buttermilk. Dilute 20 drops of rennet (for each litre of milk) in some water and stir this carefully through the milk. Place the pan in a haybox or newspapers to prevent it from cooling down. Check the next day to see if the milk has curdled sufficiently; a little whey on top is acceptable.

Cut the curd into cubes the size of a matchbox (see Figure 15). After 2 hours, transfer the mass to a cheesecloth and let it drain for 12 hours at room temperature. Mix the dry curds with some salt and put them into cheese moulds. Press the curds firmly into the mould so that no air spaces remain and place the mould in a cool (15°C) place. Remove the cheese carefully from the cheesecloth the next day and replace it upside down in the cheesecloth and mould. Leave the cheese for a further 24 hours in a cool place.

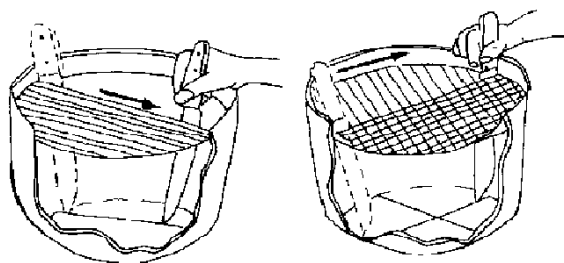


Figure 15: Cutting the curd, positioning the knife.

Remove the cheeses from the moulds and turn them daily. Should they become too dry, wrap them in grease-proof paper for example. If you wish to store the fresh goat cheeses for several weeks, place them in a large (glass) jar which can be closed. Sprinkle a mixture of different herbs over them, such as rosemary, basil, thyme, bruised juniper berries, a finely chopped piece of garlic, several pepper kernels and a chopped up hot pepper (other herbs can also be used). Pour olive oil over the cheeses until they are just covered and hang a few twigs of dill or rosemary in the oil. Close the jar and put it away in a cool and dark place. Before using the cheeses, let them drain well. Use the leftover oil for salad dressing.

Fresh goat's cheese 2

You will need pasteurised goat's milk, a heat source, pan with lid, thermometer, buttermilk or souring agent, acid, spoon, rennet, knife, colander or cheesecloth, cheese moulds, pressing equipment and salt.

Heat the pasteurised milk in a pan to 30°C, stirring all the while. For each 10 litres of milk, add 0.2-0.5 litres of buttermilk or 0.2 litres of souring agent and 30 drops of rennet. After 45 minutes, the curd is cut with a knife; after another 10 minutes, the curds will be the size of a marble. The top layer of whey can be poured off after leaving the mixture to stand a bit. The curds are left in the carefully closed pan with the rest of the whey for a further 30-45 minutes. Then transfer the curds to cheese moulds in which cheesecloth has been placed. Press the curds, one hour is sufficient. The cheeses must then be pickled in brine. For a cheese of 500 grams, 10 hours of pickling is long enough.

Fresh sheep's cheese

You will need pasteurised sheep's milk, a heat source, pan, thermometer, souring agent, rennet, spoon, knife, cheesecloth, perhaps salt and cheese mould.

Sheep's milk contains more fat and protein than cow's milk and therefore only 4-4.5 litres of sheep's milk are needed to make 1 kg. of cheese. Curdled sheep's milk looks more like a thick cake than like pudding as does curdled cow's milk. The ways of preparing fresh cheeses vary, what follows is a method to prepare fresh sheep's cheese.

Heat the pasteurised milk to about 30°C, stirring continuously. Add 300 ml of souring agent and 40 drops of rennet to each 10 litres of milk. After 45 minutes the milk will have coagulated sufficiently to be able to be cut. Cut the curdled, thick cake very carefully; continue until the curd particles are the size of a pea. Spoon the curds into a cheesecloth, if desired mix in some salt, and let the cloth hang until the cheese has the desired thickness. You can speed up the draining of the whey by opening the cheesecloth after several hours, scraping the thick part from the cloth, and mixing it in with the rest of the curds. Pour off some of the whey after curdling to pea size if you want to make a less sour cheese. After a short period of rest, cut the curds carefully again and fill the cheese mould which has been covered with a cheesecloth. Press the curds; about 4 hours of light pressing is sufficient. Store in a cool place. Sheep's cheese can be kept for at most one week in the refrigerator.

Ripened sheep's cheese

You will need pasteurised sheep's milk, heat source, pan, thermometer, buttermilk or souring agent, rennet, spoon, knife, colander, cheesecloth, cheese moulds and pressing equipment, salt, tightly sealed pickling tub, coarse cheesecloth, a cool place, moist cloth and hot water.

10 litres of sheep's milk yields about 2 kg. of ripened cheese. After adding 60 ml of souring agent or buttermilk, let the milk stand at 30°C for 30-45 minutes. Only then add 60 drops of rennet, diluted with a little water, per 10 litres of milk, and stir it thoroughly through the milk. After curdling for 1 hour, the partially formed curds are cut. After then stirring for 10 minutes, half the whey is poured off and the curds are heated to 35°C by adding hot (80-100°C) water. The second stirring of 10 minutes follows, after which the curds are left for 30 minutes in the pan; the pan is kept warm as well as possible but never placed on a fire. The whey which then separates can be removed and the curds with the remaining whey is placed in a colander. After the first draining, the curds must be transferred by hand to cheese moulds covered with cheesecloth which can be pre-heated. The curds are pressed by hand until the whey floats on top. Turn the cheese once and wring out the cloth. Spread the cloth in the mould again, press the cheese in place and fold the corners of the cloth over it again. Press the cheese for 2 to 3 hours, initially with a weight that is twice that of the cheese, later with a weight 5 times as heavy. Subsequently pickle the cheese in brine, after which it can be moved to a cool place where it must ripen for 5 to 8 weeks.

Further reading

Berg, J.C.T. van den, **Dairy technology in the tropics and sub-tropics**. 1988, PUDOC, Ede, Netherlands. ISBN: 9022009270;

Dubach, J., **Traditional cheesemaking**. 1989, Intermediate technology, London. ISBN: 946688435

FAO, **Manual on the use of IP- system in milk handling and reservation**. 1991, FAO, Rome. ISBN: 92-5-5104254-3

FAO, **Technology: Milk composition**. Small scale dairy farming manual, vol. 1, 1994.

FAO, **The Technology of traditional milk products in developing countries**. Animal health and production, paper 85, 1990, FAO, Rome. ISBN: 92-5-102899-0

www.fao.org/docrep/003/t0251e/T0251E00.htm

Lambert, J.C., **Village milk processing**. FAO Animal health and production, paper 69, 1988, FAO, Rome. ISBN: 92-5-102679-3
www.fao.org/docrep/004/t0045e/T0045E00.htm.

Matthewman R.W. **Dairying**. 1993, CTA & Macmillan, London & Wageningen. ISBN: 0-333-52313-x

O'Mahony, F., **Rural dairy technology: Experiences in Ethiopia**. ILCA manual No-4, 1988, ILCA, Addis Ababa. ISBN: 92-9053-092-8

Peacock, C., **Improving goat production in the tropics**. 1993, Oxfam, London. ISBN: 0-85598-269-1

Preston, T.R., **The development of milk production systems in the tropics**. 1989, CTA, Ede. ISBN: 92-9081-025-4

Tulachan, Pradeep Man and Arun Neupana, **Livestock in mixed farming systems of the Hindu-Kush-Himalayas: Trends and Sustainability.** 1999, ICIMOD, Kathmandu. ISBN: 92-9115-071-1

Walstra, T.J.Geurts, A. Noomen, M.A.J.S van Boeke, **Dairy Technology, principles of milk, properties and processes.** 1999, Marcel Dekker, New york. ISBN: 0-8247-0228-X

Useful addresses



PTC+ is an international training institute, which focuses on all the links in the production chain on plant and animal commodities, (agricultural) technology, (food) technology and natural areas.

Training programmes are practice-oriented and mix theory with practical classes. PTC+ offers “open entry” programmes, “tailor-made” programmes and consultancy. Programmes are offered in the Netherlands and/or at location.

It is the policy of PTC+ to search for partnerships and co-operation programmes with national and international institutions abroad.

For more information: visit our web-site www.ptcplus.com and/or write to:

PTC+ Head Office

P.O. Box 160, 6710 BD Ede, The Netherlands

Tel.: +31 318 645700

Fax: +31 318 595869

e-mail: info@ptcplus.com

Food and Agricultural Organization, (FAO)

Viale delle terme di carcalla, Rome, Italy.

E-mail: FAO-HQ@fao.org,

Website: <http://www.fao.org/ag/AGA/AGAP/LPS/dairy/intro.htm>. . .

International Livestock Research Institute (ILRI)

P.O.BOX 30709, Nairobi, Kenya.

E-mail: ILRI-Kenya@cgiar.org, Website: <http://www.ilri.cgiar.org/>

ILRI's mission is to develop animal health and productivity in the poorest regions of the world through science and multilateral cooperation.

International Livestock Research Institute

(ILRI), P.BOX 5689, Addis Ababa, Ethiopia.

E-mail: ILRI-Ethiopia@cgiar.org,

International Livestock Research Institute, (ILRI)

CG Centres' Block (1st floor), National Agric Sci Centre (NASC) Complex, Dev Prakash Shastri Marg,

(Todapur Road), near Pusa Institute, Patancheru, INDIA.

E-mail: icrisat@cgiar.org, Website: www.icrisat.org.

ICRISAT's mission is to help the poor of the semi-arid tropics through 'Science with a Human Face' and partnership-based research and to increase agricultural productivity and food security, reduce poverty, and protect the environment in SAT production systems.

C.van 't Riet Dairy

Dorpsstraat 25, 2445 AJ, Aarlanderveen, The Netherlands.

E-mail: <mailto:info@rietdairy.nl>,

Website: www.rietdairy.nl/engels/frame.htm. Used equipment.

Animal science department, WUR

Zodiac, Marijkeweg 40, 6700 PG, Wageningen

E-mail: info@animalsciences.nl, Website: <http://www.zod.wau.nl/>

Intermediate Technology Development Group, (ITDG)

Bourton Hall, Bourton on Dunsmore, CV23 9QZ, Rugby, Warwickshire, United Kingdom.

E-mail: infoserv@itdg.org.uk, Website: <http://www.itdg.org/>

Appendix 1: Measures

1 drop	= 0,05 ml
20 drops	= 1 ml
1 tablespoon	= 15 ml
1 cup	= 250 ml
1000 ml	= 1 l