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UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna International Centre, P.O. Box 300, 1400 Vienna, Austria
Tel: (+43-1) 26026-0 · www.unido.org · unido@unido.org

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Project:No. TF/RWA/99/001 –Contract No. 99/292P, Strengthening the National Capacity for Micro, Small and Medium-Scale Enterprises (MSMEs) Development in Rwanda

FINAL REPORT

1. Baking

2. Dairy Processing

    2.1 Small Scale Butter Making
    2.2 Small Scale Yoghurt Production
    2.3 Cheese Production

3. Equipment List

4. Fruit and Vegetable Drying

5. Pickles

6. Tomato Sauce/ Ketchup

    6.1 Fruit Juices
    6.2 Jams

BAKING

Locally produced baked goods are widely available in many countries. Breads and sweet breads are growing in significance in some countries, mainly in urban areas, due to their convenience and relative cheapness and with changing tastes in diet and the move away from the more traditional starchy staple foods.

Baked goods can be divided into different categories:

- Breads
- Biscuits
- Cakes
- Pastries

The main purpose of baking is to add variety to the diet and value to the raw materials – the cereal grains and flour from which they are produced. Baked goods are less prone to the development of food poisoning through the growth of undesirable bacteria than milk and meat products, but even so, particular care needs to be paid to hygiene and the quality of raw materials.

The basic principle of preservation in baked goods is the removal of micro-organisms and moisture from the product, thus increasing the potential shelf life.

Breads

Breads can be split into yeast and non-yeast breads according to the type of raising agent used. As the name suggests, yeast breads use yeast as a raising agent. The non-yeast breads may be sour dough fermentations or non-leavened types of bread such as chappatis or rotis. Yeast breads come in a variety of shapes and sizes and different flavours according to local taste and preference. A variety of flours can be used, but the most suitable one is wheat flour. Wheat flour contains a protein – gluten – that is responsible for providing the internal structure of bread. The amount of gluten in a flour depends largely on the variety and the climate in which it was grown. Flours with a high gluten content are termed 'strong' while those with little gluten are 'weak'. Strong flour is essential for bread making as it can expand and produce a very elastic dough that can trap large amounts of air, which results in a light springy loaf. Weak flour is unsuitable for making bread as it is does not have the strength to form a good dough – the bread produced is very heavy. Weak flour is suitable for cake production where there is less need for an elastic dough.

Equipment needed

Food bowls	Available locally?	
Food mixer	G, R	250
Weighing scales	as above	
Proofing cabinet	build locally?	
Large table	available locally?	
Dough molder	G	up to 1000
Rolling pins	Try G,N	
Cutting shapes	Try G,N	
Baking tins	Try G,N	
Oven	G	up to 5000
Wrapping/sealing machine	G	up to 200
Bread slicing machine	G	up to 1000

Raw materials

1kg flour
0.5 l water
30g dried yeast
2 tsp salt
2 tsp sugar
50g vegetable oil (optional)

Method

Process	*Quality control notes*
Select raw materials ↓	use **good quality**, clean flour
Mix ↓	dry ingredients, add the oil and water (at body temperature **37°C**). Mix well and knead to form an elastic dough
Ferment ↓	cover with a damp cloth or oiled polythene and leave to **prove** in a warm place (proofing cabinet at **32-35°C**) until dough has doubled in size
Knock back ↓	remove from proofing cabinet and **knead** dough to knock out the air.
Shape ↓	into individual loaves, place into loaf tins or on open trays.
Proof ↓	leave to stand in a warm place (**32-35°C**) until dough has doubled in size
Bake ↓	in a **hot oven** (200°C) for 30 to 40 minutes depending upon the size and shape of loaf.
Cool ↓	**cool** on wire racks
Package	in paper or polythene bags and seal. Loaves **must be cool** first to prevent the formation of condensation inside the package.

Baked goods such as breads and pastries typically have a shelf life of about 2 to 5 days whereas others such as biscuits and certain cakes can be stored for up to several months when correctly packaged.

DAIRY PROCESSING

Introduction

Milk is a valuable nutritious food, which if untreated has a shelf life of only a few days before it spoils. There are however, a variety of preservation techniques applied to milk to extend its shelf life to several weeks or months and also to change its qualities by developing different flavours and textures. For small-scale processing it is not possible to attempt production of dried milk powder or UHT (Ultra-High Temperature) sterilized milk, but other dairy products are potentially suitable.

To preserve milk it is necessary to destroy or inhibit the action of enzymes and contaminating bacteria. Milk is a low-acid food which contains all of the nutrients required for bacteria to grow. It is therefore a potential cause of food poisoning if not adequately processed. **In all dairy processing it is essential that full and proper hygiene precautions are taken to ensure the safety of the products.**

The four main methods of preservation suitable for small-scale operation are:

- Cooling - to extend the shelf life of fresh milk by a day or two.
- Heating - (pasteurisation, sterilisation or concentration) to destroy enzymes and micro- organisms.
- Acidification - to inhibit spoilage or food poisoning bacteria from growing and also to change the physical characteristics of milk.
- Separation - of the milk components.

Cooling

Refrigeration is expensive and milk coolers based on refrigerated brine or other coolants are unlikely to be affordable on a very small-scale. However, for cottage/village or medium-scale processing this equipment is often essential to maintain the quality of raw milk before processing and to cool processed products such as yoghurt, cheese, butter and pasteurised milk for temporary storage before distribution. This operation does not destroy bacteria or enzymes but slows down their activity to extend the shelf life of the products.

Heating

Milk should be heated to 63°C for 30 minutes to adequately pasteurise it, or in bottles to 121°C for 15-20 minutes to adequately sterilise it. Higher temperatures and shorter times are used in larger commercial operations but this type of equipment is very expensive and is not considered to be 'small scale'.

Pasteurisation can be done in open pans with continuous stirring, then filling the milk into pre-sterilised bottles (100°C for ten minutes in steam or water) and sealing immediately. Sterilisation requires the use of a pressure cooker to achieve 121°C (15 psig) which increases the capital cost of processing. Milk is filled into bottles which are sealed and placed in the pressure cooker. The temperature and pressure are *gradually* raised and lowered to give the correct processing time. Sterilised milk has a shelf life of several weeks/months if unopened but *extreme care is needed to ensure adequate heating in order to prevent food poisoning.* This is not recommended for inexperienced processors.

Boiling milk to evaporate some of the water and produce a brownish gel is a low technology process which produces a popular snack food/sweet in some parts of Asia. The product has a shelf life of a few weeks and may be used in other foods or have ingredients such as sugar, colour, spices, fruits and nuts added to give variety.

Acidification

The natural acidification of milk occurs by the presence and growth of certain types of harmless bacteria called 'lactic acid bacteria'. These bacteria convert milk sugar (lactose) into lactic acid. This increases the acidity of the milk which causes the formation of the characteristic gel of yoghurt (or curd) and inhibits bacterial growth. The shelf life is extended by several days and the changes in flavour and texture make this a popular product in most regions. The technology involved can be very simple eg inoculating milk in a loosely covered pan with some of yesterday's batch and allowing it to ferment at room temperature for several hours. More sophisticated developments include the use of new starter cultures for each batch and packaging in plastic pots sealed with hand operated foil lid sealers.

Cheese making requires more skill and experience than yoghurt production and with the exception of cottage cheese or simple curd cheese, it is recommended that training is obtained from an experienced cheese maker. There are more than 700 recognized types of cheese in the world and care should be taken to find which ones are likely to be popular in your region before contemplating production. Two excellent books on this subject are: 'Traditional Cheesemaking' by Josef Dubach, published by IT Publications/SKAT, and 'Traditional Cheesemaking Manual' by Charles O'Conner of the International Livestock Centre for Africa (ILCA). For details contact IT Publications, SKAT or ILCA at the following addresses:

IT Publications
103-105 Southampton Row
London
WC1 4HH

SKAT
Tigerbegstrasse 2
9000 St Gallen
Switzerland

International Livestock Centre for Africa
P O Box 5689
Addis Ababa
Ethiopia

Separation

Milk contains fat and a complex mixture of water, proteins and vitamins/minerals. By separating the fat from the watery part it is possible to obtain cream. This product is extremely susceptible to food poisoning and food spoilage. It is only recommended for the most experienced small-scale dairies.

By churning cream it is changed to butter which, if prepared and stored correctly, can have a shelf life of several weeks. Clarified butter (ghee) has a shelf life of several months. Both are high value products for which there is often a ready market.

In summary, yoghurt, milk gel and ghee are highly suitable for small-scale operation. Cheese, cream and pasteurised milk require greater care. Sterilised milk requires considerable care and experience to produce a safe, high quality product. Dried milk and UHT milk are not suitable for most small-scale operations.

SMALL-SCALE BUTTER MAKING

Butter can be made from fresh or fermented milk. If fresh milk is used, it must first be separated into skim milk and cream. The cream is churned and the final product is known as sweet butter.

The milk used to make lactic butter does not require separation into skim and cream. Instead milk is fermented to form yoghurt, and lactic butter is produced directly from churning of the yoghurt.

Sweet cream butter

Raw milk is first separated into skim and cream in a centrifugal separator (electrically or manually powered). Milk with a high fat content gives a higher butter yield.

The fat content in the cream is determined using a Gerbera cream butyrometer. The cream should then be standardised to approximately 40% fat content using the separated skim milk. Standardisation of cream to the correct fat content is important, because it affects the churning efficiency and thus butter yield.

Standardised cream is then pasteurised at 72°C for 15 seconds or 63°C for 30 minutes. These are minimum pasteurisation requirements, and for improved keeping quality of the butter, especially where the process is not automated and thus temperature holding times are only approximate, it is advisable to exceed the minimum heat treatment, eg 75°C for one minute.

The cream should be continually stirred during heating to ensure even heat distribution, and timing started when it reaches the correct temperature.

Pasteurised cream is then chilled below 4°C for several hours (or overnight). This 'ages' the cream and improves its churning efficiency and butter yield.

The next day, aged cream is churned either in a butter churn or a small mixer. It is important to keep the temperature as low as possible during churning. During churning, cream viscosity increases, and finally the cream 'breaks'. This is a clear separation of cream into butter grains and buttermilk. Churning should be continued until butter grains adhere together into one lump.

The buttermilk is drained off and clean, chilled water added to the butter. Slow churning cleans the butter from residual buttermilk, which reduces the keeping quality of the butter if allowed to remain. The water is drained off, and 1-2% salt (of butter weight) is added to the butter during continued slow churning, to achieve even salt distribution.

The butter is then packaged into grease-proof paper, and stored below 4°C.

Lactic butter

Whole fresh milk is pasteurised (see pasteurisation process for sweet cream butter), and then cooled to 37°C before adding a starter culture (this may be a small amount of yoghurt left over from a previous batch). The milk is then incubated for several hours (or overnight) in a warm place (30-37°C) until set. The resulting yoghurt is chilled for several hours, and then churned (see churning process for sweet cream butter). The lactic butter is salted and packaged in the same way as sweet butter. Due to the fermentation process, the keeping quality of lactic butter is not as good as that of sweet butter.

Quality control

Butter can be made without a refrigerator or the use of chilled water, but this leads to the following problems:

- If the cream is not allowed to age at a low temperature the fat globules will not develop the crystalline structure necessary for good separation of cream into butter and buttermilk.
- A high temperature during the churning process reduces the butter yield, as some of the butterfat liquifies, and is lost with the buttermilk.
- The keeping quality of butter will be reduced if stored without refrigeration. At refrigeration temperatures, butter will keep for several months, but at ambient temperatures off-odours develop after only a few days. However, in many countries, a slightly rancid flavour in butter is found quite acceptable.

The water used for 'washing' butter after the buttermilk has been drained off must be potable, as otherwise it will re-contaminate the pasteurised butter, and reduce its keeping quality.

An anti-oxidant such as BHA (butylated hydroxy anisole) or BHT (butylated hydroxy toluene) may be added to butter to extend its keeping quality at concentration not exceeding 0.02%, but this may not be readily available, and may be expensive.

Lactic butter can be made more easily than sweet cream butter on a small scale, as it does not require the use of a separator or butyrometer, and the chilling stage is less important

Equipment required

Cream butyrometer
Centrifugal separator (manual)
Thermometer
Heater
Stirrer
Churn or high speed blender
Grease-proof paper
Chiller or refrigerator

SMALL SCALE YOGHURT PRODUCTION

Yoghurt is produced by the controlled fermentation of milk by two species of bacteria – Lactobacillus species and Streptococcus species. The sugar in milk (lactose) is fermented to form lactic acid. It is the lactic acid that causes the characteristic curd to form and helps to preserve the yoghurt. Under proper storage conditions, yoghurt can be store for up to ten days.

Yoghurt production is one of the traditional old household methods of preserving milk and extending its shelf life. It can easily be produced at the small scale, utilising very little in the way of equipment. However, if yoghurt is to be produced for sale, as with all food products and especially with dairy produce, extreme care must be taken over cleanliness and hygiene to avoid the dangers of food poisoning.

The science behind making yoghurt is in the culturing. Fresh milk contains many acid and flavour producing micro-organisms, but there are only two of these which work together to turn milk or cream into yoghurt - *Streptococcus thermophilus* and *Lactobacillus bulgaricus*. These are found together along with many other organisms in fresh milk. If milk is kept warm it will sour because of the lactic acid forming bacteria that will be the first to grow, competing with the desirable strains. It is therefore necessary to start the process for the manufacture of cultured products by pasteurising, boiling or simmering the milk to stop or slow the growth of the unwanted bacteria. The heating of the milk also removes most of the oxygen providing a better medium for the growth of the Lactobacillus species.

Equipment needed

Milk collecting vessels
Thermometer
Pasteurising pan, preferably made from stainless steel
Heat source
Incubation box or flask
Refrigerator
Weighing scales

Method

Process	*quality control notes*
Collect milk ↓	in clean, covered vessels
Pasteurise ↓	heat to 80 – 85°C for 15-20 minutes
Cool ↓	rapidly cool to 40-45°C
Inoculate ↓	add starter culture of the yoghurt (5g per litre of milk or two teaspoons of live yoghurt)
Ferment ↓	maintain at 40-45°C for 3 to 4 hours while fermentation takes place
Cool ↓	refrigerate
Store	for up to 10 days in a refrigerator

NOTE: Preparation of starter.

The starter is defined as milk containing the two strains of actively growing bacteria and is prepared by using a freeze dried culture, 5 gms to a litre or quart or milk, or one or two teaspoons of a fresh commercial plain or natural yoghurt. This starter can be maintained in an actively growing state for a long time by transferring small amounts into fresh milk daily or weekly, but it is much easier if each time you prepare yoghurt you save a few grammes to be the starter for next time.

Potential problems in yoghurt production

There are three potential areas for problems in yoghurt making:

- *Spoilage by bacteria and moulds*

This is due to unclean equipment, contaminated milk or poor hygiene of the production staff. Ensure that all equipment is thoroughly scrubbed, sterilised with diluted bleach (two tablespoons of bleach per gallon of water) and thoroughly rinsed in clean water before production. Pasteurisation should ensure that the milk is free from contamination, but do not use old milk. Ensure that all those handling the milk follow strict hygiene rules.

- *Maintenance of correct incubation temperature*

It is important to maintain the correct incubation temperature to allow the yoghurt to develop and to ensure consistency between batches. A commercial yoghurt maker can be purchased, but these tend to be rather expensive and not very useful. A home-made incubation chamber can be made from a shallow water bath, heated by an electric element and controlled with a simple thermostat. An alternative method is to ferment the yoghurt in a commercial vacuum flask. Another way is to make indentations in a block of polystyrene into which individual yoghurt pots can be fitted. The yoghurt is poured into the pots and covered with a polystyrene lid for insulation and allowed to ferment in the pot.

- *Yoghurt culture*

The correct balance of Lactobacillus bacteria is important for good quality yoghurt. In some places, a commercial started culture of lactobacillus can be purchased. This is 'grown' on milk and can be kept in a refrigerator until it is needed. Part of the 'master' culture is used each day to start a new batch and the last part re-inoculated into milk to for a new master culture. Provided that good hygiene is observed, this method of producing a starter culture can last for a few months. Eventually, the culture will become contaminated by undesirable bacteria and a new starter will need to be purchased.

If a refrigerator is not available, it is possible to use a tablespoon of the previous days yoghurt to inoculate the next days batch, but this method is more prone to variation and to contamination of the final product.

Other common problems in yoghurt production

Problem	Solution
Yoghurt fails to set after the normal time of incubation	The milk should be fresh, with no bacterial load to compete with the starter organisms
	Temperature maybe too high when the starter was added (over 50°C)
	Maintain incubation temperature between 43-44°C.
	Starter added when milk was too cold. Less than (37°C).
A liquid (whey) forms on the top of the yoghurt, or it has a grainy texture:	Milk was too hot when the starter was added
	The time of incubation was too long.
	The level or amount of starter was too high and/or it was not properly stirred into the pasteurised milk

Variations

Yoghurt can either be set or stirred. Stirred yoghurt is fermented in bulk, stirred and then poured into individual pots or customers containers for sale. Set yoghurt is made by pouring the inoculated yoghurt into individual pots and allowing it to ferment in the pots. Fruit and nuts can be added to each type to make variations in flavour, but care must be taken to ensure that they are clean and blanched.

Thicker yoghurts can be made by adding dried skimmed milk (approx 50g per litre) to the milk before pasteurising.

The differences in milk

Taste varies sometimes only subtly from whole milk to powdered milk, but with the proper techniques all milk, even goat's or soy milk, will make a very good tasty yoghurt. Whole milk has the highest solids content and will produce a firmer texture.

Two percent (2%) milk is the middle of the road between whole and skim milk as it contains about half of the fat of whole milk. UHT or sterilised whole milk can be used to make yoghurt, in this case it is not necessary to sterilise again, but only heat to the temperature for incubation, 43-44^{0}c.

CHEESE PRODUCTION

Cheese is made from milk by the combined action of lactic acid bacteria and the enzyme rennin (known as rennet). Essentially, cheese is a concentrated form of milk protein, with most of the water removed. There are numerous types of cheese produced around the world, the main differences being in the type and composition of milk, the individual process and the bacteria used. Cheeses are classified as hard or soft types, depending upon the structure, which is determined by the amount of whey remaining in the cheese. Hard cheeses such as cheddar and edam type cheeses have most of the whey pressed out while soft cheeses such as paneer and most traditional 'country' cheeses are not pressed and contain a significant amount of whey. The hardness, flavour and other qualities of cheese can be varied by the process conditions to suit local tastes. However, the basic principles of cheese making are the same.

The basic principles of preservation are as follows:

- Raw milk is pasteurised to destroy most enzymes and contaminating bacteria.
- Fermentation by lactic acid bacteria to increase the acidity and inhibit the growth of food poisoning and spoilage bacteria
- Lowering of the moisture content and addition of salt to inhibit bacterial and mould growth.

Equipment needed

Cooler/refrigerator
Milk collection containers
Pasteuriser
Thermometer
Starter culture
Cutting frame
Cheese knives
Cheese press
Cheese cloths

Raw materials

Milk
Starter culture
Rennet

Milk should be fresh and free from contamination. It should be pasteurised as soon as it is received to destroy enzymes and contaminating bacteria. It should be cooled rapidly and kept cool and free from contaminants and strong odours.

Rennet is added to produce a firmer curd. Rennet is an enzyme obtained from the stomach of calves. Commercial sources of rennet are available, but may be expensive. If they are not available, a curd can be formed by the addition citric acid – this is often the case with home-produced 'country' cheeses.

Method

Process	*quality control notes*
Collect raw milk	ensure all collecting vessels are clean and the milk is fresh and free from contamination
Pasteurise ↓	heat to 63°C for 30 minutes – use an aluminium or stainless steel pan
Cool ↓	with stirring to 35-40°C (ideal temperature for the starter culture to work)
Inoculate ↓	add starter culture – 2% of the weight of milk. Use an aluminium or stainless steel pan.
Add rennet ↓	add rennet at 30°C - 1% of the weight of milk – this allows the milk to separate into curds and whey.
Incubate ↓	allow to stand for about 30 minutes until curds form
Cut the curd ↓	cut the curd with a spatula (or cheese knife) into cubes to facilitate the elimination of whey. Stand for 5 to 10 minutes to allow the curd to firm.
Heat ↓	slowly increase temperature to 40°C in 20 minutes to firm the curd
Drain ↓	drain through a filter cloth to remove whey
Cut ↓	to a size that fits in cheese mould (if used) – or appropriate sized pieces.
Press ↓	put in cheese mould, press with weights until whey is removed
Cool ↓	and dry at 10-12°C
Salt ↓	place in brine solution (20% brine solution) at 12°C for 12 to 16 hours.
Ripen ↓	stand for 6-8 weeks at 16°C to allow the flavour to develop. Temperature and humidity of the ripening room should be controlled
Wash ↓	wash in clean water, dry for 30 minutes
Wax ↓	use paraffin wax to coat cheese
Store	in a cool place (4-10°C). Hard cheese can be stored for several weeks

Equipment list

General food processing equipment

There are several basic items of equipment that are required for all the food products identified in the report. These include food grade bowls (plastic and metal), plastic buckets, cleaning and washing equipment, knives and other cutters, spoons, stainless steel boiling pans, weighing scales, bottle filler and sealers, label gumming machinery and heat sources. These basic items are listed first. Other more specific pieces of equipment are required for the individual products and these are listed under the relevant heading. Presumably much of the basic equipment will be available in-country, although it can also be purchased from overseas suppliers along with the more specific equipment.

In addition, the food processing room should be equipped with large tables, heat sources (preferably whatever is available locally), refrigerators, cool storage area, running water.

The majority of the equipment required is available from three or four main manufacturers and suppliers in India. These suppliers are very competitively priced and therefore it is recommended that all equipment is purchased from them. Rank and Company, Gardners Corporation and Narangs Corporation all supply a range of equipment, both manually operated and electrically powered. Dairy Udyog specialise in a wide range of dairy equipment, most of which can also be used for other operations.

In addition to food processing equipment, a selection of packaging materials will be required. This will include glass jars and bottles for the preserves, pickles and fruit juices; polypropylene or polyethylene bags for the dried and baked products; plastic or glass containers for the yoghurt.

Specific ingredients that might not be readily available in-country include pectin solution and starter culture for yoghurt and cheese.

Midway Technology (UK) can source and supply minor ingredients such as pectin and starter cultures and packaging materials and other equipment. They also have several contacts with suppliers of small and medium scale machinery which may be difficult to locate.

Main suppliers

Gardners Corporation (G)
6 Doctors Lane
Near Gole Market
PO Box 299
New Delhi 110 001
INDIA

Tel: 0091 11 334 4287/ 336 3640
Fax: 0091 11 371 7179

Narangs Corporation (N)
P-25 Connaught Place
New Delhi – 110 001
INDIA

Tel: 0091 11 336 3547
Fax: 0091 11 374 6705

Dairy Udyog (D)
C-230 Ghatkopar Industrial Estate
L B S Marg
Ghatkopar (West)
Bombay, 400 086
INDIA

Tel: 0091 22 517 1636/ 517 1960
Fax: 0091 22 517 0878

Rank and Company (R)
A-95/3
Wazirpur Industrial Estate
New Delhi 110 052
INDIA

Tel: 0091 11 7456 101/2/3/4
Fax: 0091 11 7234 126/ 743 3905

Midway Technology Ltd
St Oswalds Barn
Hay on Wye
HR3 5HP
UK

Other suppliers

J T Jagtiani
National house
Tulloch road
Apollo Bunder
Bombay, 400 039
INDIA

Central Institute of Agricultural Engineering
Nabi Bagh
Bersala Road
Bhopal, 462 018
INDIA

Ashoka Industries
Kirama
Walgammulla
Sri Lanka

0094 71 764725

General equipment

Item	Supplier	Price ($US)
Stainless steel boiling pans	G,N,D	10-100
Choppers/knives	G	2-450
Thermometer	D	25-100
Refractometer	G, N	40-50
Washing tank	R	
Bottle steriliser	G, D, R	up to 200
Bottle filler	R	
Bottle capper	R, G	up to 200
Weighing scales	G	up to 200
Label gummer	N,R	

Specific equipment

1. Tomato sauce/ketchup

Pulper	G	700
Boiling pans (stainless steel)	as above	
Tilting pan	N	
Refractometer	as above	
Thermometer	as above	
Washing tank	as above	
Bottle filler	as above	
Capper	as above	
Weighing scales	as above	
Bottle steriliser	as above	

2. Fruit juices and jams

<u>Juices</u>

Juice extractor	G, N	70-130
Filter (bags)	G	10
Filter unit	G	140-190
Boiling water bath	N G R D	425
Capper	as above	
Bottle filler	as above	
Bottle steriliser	as above	
Pasteuriser	D,G	

<u>Jams/jellies</u>

Juice extractor	G	70-130
Peeler	G	
Sieve	G	10
Straining bag/equipment	G	10
Scales	as above	
Refractometer	as above	
Boiling pans (stainless steel)	as above	
Tilting pan	N	
Thermometer	as above	
Solid filler	R,G	up to 1000
Sealing machine	G,R	up to 200
Label gummer	as above	

3. Fruit and vegetable drying

Peelers	G	
Choppers/knives	as above	
Steam blancher/pressure cooker	G,D	500
Stainless steel boiling pans	as above	
Scales - up to 10kg	as above	
Up to 500g	as above	
Sulphur tent/cabinet		
Food grade tank (stainless steel)	D, R,	
Drier solar drier	Nigeria, Pakistan	
Fuel fired drier	Hohenheim	
Electric drier	R	
Sealing machinery (bags)	G	400

4. Pickling

PH meter	D	365
Refractometer	as above	
Thermometer	as above	
Boiling pans (stainless steel)	as above	
Peelers	G	
Choppers/knives	as above	
Weighing scales	as above	
Filling machine	G	up to 2000
Capping machine	R, G	up to 200
Sealing machine	G	400
Pasteuriser	D, G	
Bottle steriliser	as above	
Large food grade tanks	D, R	
Label gummer	as above	

5. Baking

Food bowls	Available locally?	
Food mixer	G, R	250
Weighing scales	as above	
Proofing cabinet	build locally?	
Large table	available locally?	
Dough molder	G	up to 1000
Rolling pins	Try G,N	
Cutting shapes	Try G,N	
Baking tins	Try G,N	
Oven	G	up to 5000
Wrapping/sealing machine	G	up to 200
Bread slicing machine	G	up to 1000

6. Milk processing (cheese, yogurt)

Refrigerator	D, available locally?	
Boiling pans	as above	
Thermometer	as above	
Weighing scales	as above	
Liquid filler	as above	
Incubator/ insulated cabinet	D	875
Curd cutters	D	210
Filter cloth	D	5.5-12
Knives	D	235
Cheese moulds	D	350
Cheese press	D	1300
Brine meter	D	190
Refrigerated storage	D, available locally?	
Storage racks	D, construct locally	

Optional high tech equipment

Milk boiler (capacity 50l)	D	1750
Milk boiler (capacity 100l)	D	2850
Pasteuriser process unit – batch type Capacity 500l per day	D	17500
Pasteuriser continuous process	D	22500

FRUIT AND VEGETABLE DRYING

Drying is one of the most popular methods of food preservation employed by small and medium scale food processors. At its most simple, drying foods can be carried out with the minimum of equipment, utilising the heat from the sun. At a more advanced level however, a range of driers of various capacities and complexities are available. They have several advantages over drying in the sun:

- the process is speeded up
- drying can be carried out in adverse weather conditions (rain, high humidity, no wind) and at night
- the temperature and rate of drying can be controlled, thus products of a consistent and higher quality are easier to produce

The principles of drying

Drying is used to remove water from foods for two reasons
- to prevent (or inhibit) the growth of micro-organisms and hence preserve the food
- to reduce the weight and bulk of food for cheaper transport and storage.

When carried out correctly, the nutritional quality, colour, flavour and texture of rehydrated foods are slightly less than fresh food, but for most people this has only minor nutritional significance as dried foods form one component in the diet.

However, if drying is carried out incorrectly there is a greater loss of nutritional and eating qualities and more seriously, a risk of microbial spoilage and possibly even food poisoning.

Requirements for drying

For effective drying, air should be **HOT**, **DRY** and **MOVING.** These factors are inter-related and it is important that each factor is correct (for example, cold moving air or hot, wet moving air are each unsatisfactory). The dryness of air is termed 'humidity' -the lower the humidity, the drier the air. There are two ways of expressing humidity (or RH) the most useful is a ratio of the water vapour in air to air which is fully saturated with water. So 0% RH is completely dry air and 100% RH is air that is fully saturated with water vapour.

Air can only remove water from foods if it is not fully saturated and therefore has the capacity to hold extra water. Therefore, the most effective form of drying is to blow low RH (or dry) air over foods. If high RH (or wet) air is used it quickly becomes saturated and can not pick up further water vapour from the food.

The temperature of the air affects the humidity (higher temperatures reduce the humidity and allow the air to carry more water vapour). The relationship between temperature and RH is conveniently shown on a psychrometric chart (Figure 1).

Note that there are two types of air temperature - the dry bulb and wet bulb temperature:

The temperature of the air, measured by a thermometer bulb, is termed the dry-bulb temperature. If the thermometer bulb is surrounded by a wet cloth, heat is removed by evaporation of the water from the cloth and the temperature falls (to the 'wet bulb' temperature). The difference between the two temperatures is used to find the relative humidity of air on the psychrometric chart.

The dew point is the temperature at which air becomes saturated with moisture (100% RH) and any further cooling from this point results in condensation of the water from the air. This is seen at night when air cools and water vapour forms as dew on the ground. Adiabatic cooling lines are the parallel straight lines sloping across the chart, which show how absolute humidity decreases as the air temperature increases.

The psychrometric chart is useful for finding changes to air during drying and hence the efficiency of a drier. The following examples show how it is used.

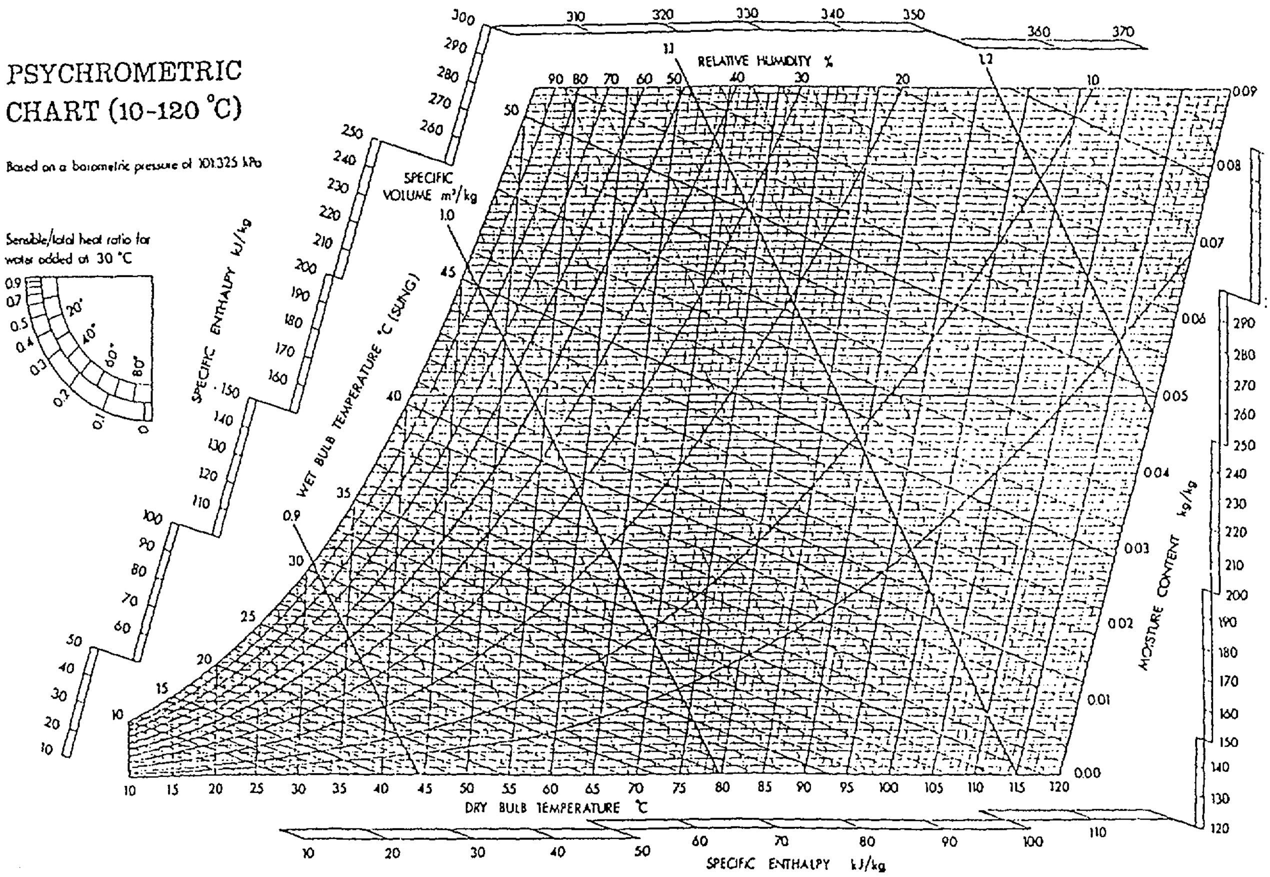

Figure 1

Using Figure 1, find:

1 the absolute humidity of air which has 50% RH and a dry-bulb temperature of 60°C
2 the wet-bulb temperature under these conditions
3 the RH of air having a wet-bulb temperature of 45°C and a dry-bulb temperature of 75°C
4 the dew point of air cooled adiabatically from a dry-bulb temperature of 55°C and 30% RH
5 the change in RH of air with a wet-bulb temperature of 39°C, heated from a dry-bulb temperature of 50°C to a dry-bulb temperature of 86°C
6 the change in RH of air with a wet-bulb temperature of 35°C, cooled adiabatically from a dry-bulb temperature of 70°C to 40°C.

Answers

1 0.068kg per kilogram of dry air (find the intersection of the 60°C and 50% RH lines, and then follow the chart horizontally right to read off the absolute humidity)
2 46.5°C (from the intersection of the 60°C and 50% RH lines, move left parallel to the wet-bulb lines to read off the wet-bulb temperature)
3 20% (find the intersection of the 45°C and 75°C lines and follow the sloping RH line upwards to read off the % RH)
4 36°C (find the intersection of the 55°C and 30% RH lines and follow the wet-bulb line left until the RH reaches 100%)
5 50-10% (find the intersection of the 39°C wet-bulb and the 50°C dry-bulb temperatures, and follow the horizontal line to the intersection with the 86°C dry-bulb line; read the sloping RH line at each intersection (this represents the changes that take place when air is heated prior to being blown over food))
6 10-70% (find the intersection of the 35°C wet-bulb and 70°C dry-bulb temperature, and follow the wet-bulb line left until the intersection with the 40°C dry-bulb line; read sloping RH line at each intersection (this represents the changes taking place as the air is used to dry food; the air is cooled and becomes more humid as it picks up moisture from the food).

If a new type of drier is to be used, or if a different type of food is to be dried, it is necessary to do some experiments to find the rate of drying. The information can then be used to find the time that the food should spend in the drier before the moisture content is low enough to prevent spoilage by micro-organisms. The rate of drying also has an important effect on the quality of the dried foods and (in artificial driers) the fuel consumption. To find the rate of drying you will need a clock/watch and a set of scales. Food is weighed, placed in the drier and left for 5-10 minutes.

It is then removed, reweighed and replaced. This is continued until the weight of the food no longer changes. The interval between weighings can be increased when the changes in weight start to become less. You should also make a note of the wet and dry bulb temperatures of the air inside the drier and the air outside. The results are plotted on a graph (Figure 2) and show two distinct phases of drying - the 'constant' and 'falling' rate periods. In the constant rate the surface of the food remains wet and it can therefore be spoiled by moulds and bacteria. In the falling rate the surface is dry and the risk of spoilage is much smaller. The food should therefore be dried to a weight that corresponds to the end of the constant rate period as quickly as possible (however see 'case hardening' below).

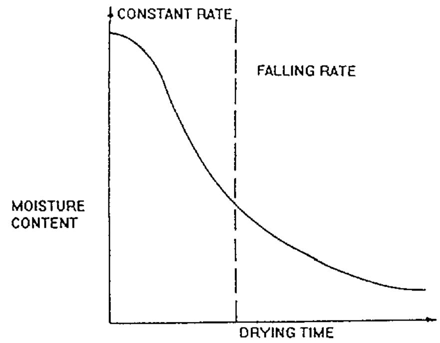

Figure 2

The information from an experiment can be more usefully shown as in Figure 3, by calculating drying rate for each 10 minute period as follows:

$$\text{Drying rate} = \frac{\text{initial weight - final weight}}{\text{time interval (eg 10 minutes)}}$$

The moisture content of both the fresh food and the final dried food can be found by weighing the food, heating at 100°C in an oven for 24 hours and reweighing. The moisture content is found as follows:

$$\text{Moisture content (\%)} = \frac{\text{initial weight - final weight x 100}}{\text{initial weight}}$$

Other values of moisture content during the drying period can be found by relating these two results to the weights of food recorded during the drying experiment and applying similar factors to intermediate weights. Figure 3 gives two important pieces of information:

1 The actual drying rate during the constant rate period which shows how efficient the drier is.

2 The final moisture content of the dried food which shows whether it will be stable during storage.

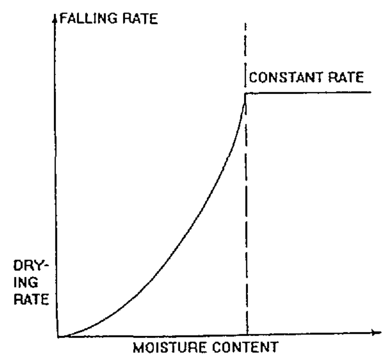

Figure 3

Typically, a drying rate of 0.25kg/hr would be expected for solar driers depending on the design and climate, and 10-15kg/hr for artificial driers. To ensure safe storage **the final moisture content of the food should be less than 20% for fruits and meat, less than 10% for vegetables and 10-15% for grains.**
If the drying rate is lower than this, the air temperature or speed is too low and/or the RH is too high. This can be checked by the temperature measurements made during the experiment and by using the psychrometric chart.

Normally the air in the drier should be 10-15°C above room temperature in solar driers and 60-70°C in artificial driers. The RH of air entering the drier will vary according to local conditions, but should ideally be below about 60% RH.

The stability of a dried food during storage depends on its moisture content and the ease with which the food can pick up moisture from the air. Clearly the risk of moisture pick up is greater in regions of high humidity. However, different foods pick up moisture to different extents (compare for example the effect of high humidity on salt or sugar with the effect on pepper powder -salt and sugar pick up moisture, pepper doesn't).

For foods that readily pick up moisture it is necessary to package them in a moisture proof material.

A low moisture content is only an indication of food stability and not a guarantee. It is the availability of moisture for microbial growth that is more important and the term *Water Activity* (aw) is used to describe this. Water Activity varies from 0-1.00 and the lower the value the more difficult it is for micro-organisms to grow on a food.

Examples of moisture contents and aw values for selected foods and their packaging requirements are shown in Table 1.

Food	*Moisture Content %*	*Water activity*	*Degree of protection required*
Fresh meat	70	0.985	Package to prevent moisture loss
Bread	40	0.96	
Marmalade	35	0.86	
Rices	15-17	0.80	Minimum protection or no packaging required
Wheat flour	14.5	0.72	
Raisins	27	0.60	
Macaroni	10	0.45	
Marzipan	15-17	0.75	
Oats	10	0.65	
Nuts	18	0.65	
Toffee	8	0.60	Packaged to prevent moisture dried uptake
Cocoa powder		0.40	
Boiled sweets	3.0	0.30	
Biscuits	5.0	0.20	
Milk	3.5	0.11	
Potato crisps	1.5	0.08	
Spices	5-8	0.50	
Dried vegetables	5	0.20	
Breakfast cereal	5	0.20	

Table 1

Case hardening and other effects of drying

Case hardening is the formation of a hard skin on the surface of fruits, fish and some other foods which slows the rate of drying and may allow mould growth. It is caused by drying too quickly during the initial (constant rate) period and can be prevented by using cooler drying air.

Other changes to foods include colour loss, flavour loss and hardening. Experiments with air temperature and speed can be used to select the best conditions for each food. The colour of many fruits can be preserved by dipping in a solution of 0.2-0.5% sodium metabisulphite or by exposing to sulphur dioxide in a sulphuring cabinet (Figure 4).

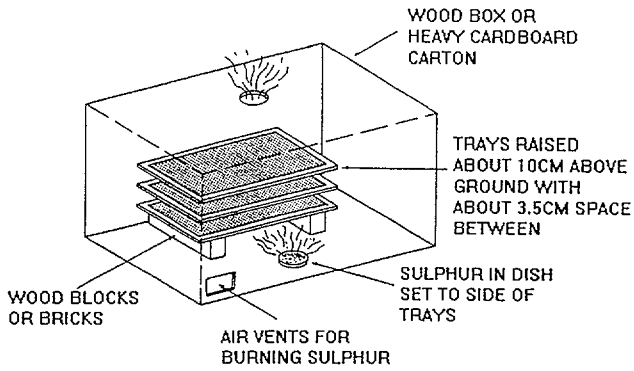

Figure 4

Vitamin losses are often greater during peeling/slicing etc than during drying. Loss of fat soluble vitamins can be reduced by shade drying and loss of water soluble vitamins by careful slicing using sharp knives. Blanching of vegetables is necessary before drying and water soluble vitamins are also lost in this stage. It should be noted that drying does not destroy micro-organisms and only inhibits their growth.

So heavily contaminated fresh foods will become heavily contaminated dried and rehydrated foods. Blanching is one method of reducing the levels of initial contamination. Thorough washing of fresh foods should be done routinely before drying.

Summary of small-scale drying equipment available

Solar driers

Solar drying is popular with agencies and research stations. However, there are no small-scale solar driers that are yet operating economically. There are a number of reasons for this:

- The amount of food lost in traditional drying is often over estimated (people report the worst case and the average amount).
- The loss of quality is not necessarily reflected in lower prices. People are willing to pay nearly the same amount for discoloured or damaged foods and there is therefore no incentive for producers to risk higher amounts of money in a drier when there is not a great return.
- Different quality standards are applied by agencies and rural people. It is not necessary to achieve export quality for sale in rural areas.
- Driers are only needed in villages if the weather is unsuitable for traditional methods. If these conditions are not very common, the drier will not be needed. Even short periods of sunshine are enough to prevent serious crop losses. Some producers wait for sunshine rather than risk the expense of using a drier. The food is then either spoiled or the drier is not big enough to handle the amounts involved.
- Other methods are available to preserve the food if it rains during harvest, for example the harvest can be delayed, food can be stacked in a way which prevents it from getting wet, or small amounts can be dried over a kitchen fire, or mixed with dry crop.
- Some benefits of proper drying (for example absence of mould, and better milling characteristics of grains) cannot be seen and there is therefore no increase in value of the food.

Other disadvantages of both solar and mechanical driers include greater space and labour requirements than traditional methods (for example loading, unloading of trays). These costs are given lower value by agencies than by villagers.

Solar driers operate by raising the temperature of the air to between 10-30°C above room temperature. This makes the air move through the drier and also reduces its humidity.

There are advantages to solar drying as follows:
The higher temperature, movement of the air and lower humidity, increases the rate of drying. Food is enclosed in the drier and therefore protected from dust, insects, birds and animals. The higher temperature deters insects and the faster drying rate reduces the risk of spoilage by micro-organisms. The higher drying rate also gives a higher throughput of food and hence a smaller drying area. The driers are water proof and the food does not therefore need to be moved when it rains. Driers can be constructed from locally available materials and are relatively low cost.

Designs vary from very simple direct driers (for example a box covered with plastic to trap the sun's heat) to more complex indirect designs which have separate collectors and drying chambers. The most common type of collector is a bare galvanised iron plate which is painted matt black. These give a temperature increase of 10°C and increase the air speed to about 5m/s.

The collectors are covered with a transparent material to ensure uniform airflow. Glass covers are best but they break easily and are heavy and expensive. Plastic often has poor stability to sunlight and weather, but is about 10% of the weight of glass and does not break. The best types of plastic are polyester and polycarbonate when available. Polythene is cheaper and more widely available but is not as strong and is less resistant to damage by light and weather.

The food can be either exposed to the sunlight (in direct systems) or heated air is passed over shaded food in indirect systems. Direct systems are used for food such as raisins, grains and coffee where the colour change caused by the sun is acceptable, but most foods need indirect systems to protect the colours in the food. Other types of driers use fans to blow the air over the food but this adds to the capital and operating cost and removes the advantages of driers in rural areas which can not operate without electricity.

There are three basic types of drier, each of which has many variations.

1. tent driers (direct)
2. cabinet driers (direct or indirect)
3. chimney driers (indirect).

Each of these types uses natural air circulation although it is possible to fit an electric or wind powered fan to increase the speed of the air.

Tent drier - Figure 5

This type consists of a ridge tent framework, covered in clear plastic on the ends and the side facing the sun, and black plastic on the base and the side in shade. A drying rack is placed along the full length of the tent. The bottom edge of the clear plastic is rolled around a pole, which can be raised or lowered to control the flow of air into the drier. Moist air leaves through holes in the top corners of the tent.

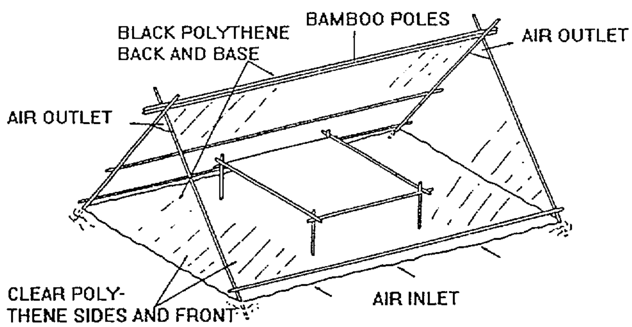

Figure 5

The advantages of this type of drier are the low construction costs and simplicity of operation. However, like other types of solar drier, there is relatively poor control over the RH of the air in the drier and so, poor control over drying rates. It is also lightweight and fairly fragile when moved or in windy conditions.

Cabinet drier - Figure 6

The basic design is an insulated rectangular box, covered with clear glass or plastic. There are holes in the base and upper parts of the box to allow fresh air to enter and moist air to leave. The inside of the cabinet is painted black to act as a solar collector. In indirect types, a flat plate is painted black and suspended in an insulated frame. Air is heated on both sides of the plate before passing into the drying cabinet. Food is placed on perforated trays within the cabinet and warm air from the collector rises up through the food and leaves through the top. The length of the cabinet is approximately three times the width to prevent shading by the side walls. The sides can be made from board or mud-coated basket work.

Larger models can be made from mud, brick or cement. The insulation can be wood shavings, sawdust, coconut fibre, dried grass or leaves, but should be at least 5cm thick to keep the inside temperature high. If insects are a problem, the air holes should be covered with mosquito netting. Drying trays should be made from basket work or plastic mesh. Metal should not be used as it can react with the acids in fruits and some vegetables and cause off-flavours in the food. These type of driers are used for fish, fruit, vegetables, root crops and oilseeds. They have capacities of up to 1 tonne.

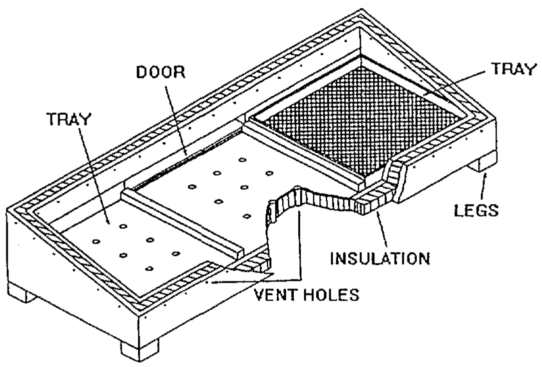

Figure 6

Chimney drier

This is a modified cabinet drier in which a solar collector of black plastic or burnt husks is covered by clear plastic on a wooden framework. A black plastic chimney heats up the air above the exit to the drier and therefore increases the airflow through the drier.

Artificial (mechanical) drier

These use fuel to increase the air temperature, and reduce the RH and fans to increase air speed. They give close control over the drying conditions and hence produce high quality products. They operate independently of the weather and have low labour costs. However, they are more expensive to buy and operate than other types of driers. In some applications, where consistent product quality is essential, it is necessary to use mechanical driers.

Light bulb drier

This consists of an electric light bulb inside a wooden box. If electricity is available this is a simple, low cost drier which may be suitable for home preservation. The capacity is very small and it is not likely to be useful for income generation. The bottom of a box is painted black, or covered in soot or black cloth. The sides are covered in shiny material (for example aluminium paint) to reflect the heat onto the black surface. Air circulates by natural convection in a similar way to the solar cabinet drier, but in this case the drier can operate all night as well as all day.

Cabinet drier

The design is similar to the solar type but in this case the heat is supplied by burning fuel or electricity. If electricity is available, a fan can be used to increase the speed of air moving over the food and therefore increase the rate of drying. To be economical it is likely that this type of drier should be relatively large (1-5 tonnes). These are successfully used for drying herbs, tea and vegetables.

PICKLES

Pickling is one of the oldest traditional methods of preserving fruits and vegetables and as a result there are many examples of pickled products around the world. Pickles make an interesting accompaniment to a bland starchy meal, adding taste, variety and extra nutritional value. In some cultures, pickled products are the mainstay of the diet.

There are two distinct methods of pickle production:

- Lactic acid fermentation, either with or without the addition of salt
- Preservation of the fruit or vegetable in acetic acid (vinegar)

Lactic acid bacteria pickling is still carried out at the domestic scale. However industrial scale processes have been developed for most types of pickles. Pickles can be made by storing prepared vegetables in a weak brine solution, by dry salting or allowing the vegetables to ferment without salt.

Lactic acid fermentation's

The lactic acid bacteria are the most important bacteria in desirable food fermentation', being responsible for the fermentation of sour dough bread, sorghum beer, all fermented milks, cassava (to produce *gari* and *fufu*) and most "pickled" (fermented) vegetables.

The whole basis of lactic acid fermentation centres on the ability of lactic acid bacteria to produce acid, which then inhibits the growth of other non-desirable organisms. All lactic acid producers are micro-aerophilic, that is they require small amounts of oxygen to function

Leuconostoc mesenteroides is a bacterium associated with the sauerkraut and pickle fermentation's. This organism initiates the desirable lactic acid fermentation in these products. It differs from other lactic acid species in that it can tolerate fairly high concentrations of salt and sugar (up to 50% sugar). *L. mesenteroides* initiates growth in vegetables more rapidly over a range of temperatures and salt concentrations than any other lactic acid bacteria. It produces carbon dioxide and acids which rapidly lower the pH and inhibit the development of undesirable micro-organisms. The carbon dioxide produced replaces the oxygen, making the environment anaerobic and suitable for the growth of subsequent species of lactobacillus. Removal of oxygen also helps to preserve the colour of vegetables and stabilises any ascorbic acid that is present.

Acetic acid fermentation's

A second group of bacteria of importance in food fermentation's are the acetic acid producers from the *Acetobacter* species. *Acetobacter* are important in the production of vinegar (acetic acid) from fruit juices and alcohol's. The same reaction also occurs in wines, oxygen permitting, where the *acetobacter* can cause undesirable changes – the oxidation of alcohol to acetic acid. This produces a vinegary off-taste in the wine.

Conditions required for bacterial fermentations

Micro-organisms vary in their optimal pH requirements for growth. Most bacteria favour conditions with a near neutral pH (7). The varied pH requirements of different groups of micro-organisms is used to good effect in fermented foods where successions of micro-organisms take over from each other as the pH of the environment changes. Certain bacteria are acid tolerant and will survive at reduced pH levels. Notable acid-tolerant bacteria include *the Lactobacillus* and *Streptococcus* species, which play a role in the fermentation of dairy and vegetable products.

Oxygen requirements vary from species to species. The lactic acid bacteria are described as microaerophilic as they carry out their reactions with very little oxygen. The acetic acid bacteria however, require oxygen to oxidise alcohol to acetic acid. In vinegar production, oxygen has to be made available for the production of acetic acid, whereas with wine it is essential to exclude oxygen to prevent oxidation of the alcohol and spoilage of the wine.

Temperature

Different bacteria can tolerate different temperatures, which provides enormous scope for a range of fermentation's. While most bacteria have a temperature optimum of between 20 to 30°C, there are some (the thermophiles) which prefer higher temperatures (50 to 55°C) and those with colder temperature optima (15 to 20°C). Most lactic acid bacteria work best at temperatures of 18 to 22°C. The *Leuconostoc* species which initiate fermentation have an optimum of 18 to 22°C. Temperatures above 22°C, favour the *lactobacillus* species.

Salt concentration

Lactic acid bacteria tolerate high salt concentrations. The salt tolerance gives them an advantage over other less tolerant species and allows the lactic acid fermenters to begin metabolism, which produces acid, which further inhibits the growth of non-desirable organisms. Leuconostoc is noted for its high salt tolerance and for this reason, initiates the majority of lactic acid fermentation's.

Water activity

In general, bacteria require a fairly high water activity (0.9 or higher) to survive. There are a few species which can tolerate water activities lower than this, but usually the yeasts and fungi will predominate on foods with a lower water activity.

Hydrogen ion concentration (pH)

The optimum pH for most bacteria is near the neutral point (pH 7.0). Certain bacteria are acid tolerant and will survive at reduced pH levels. Notable acid-tolerant bacteria include *the Lactobacillus* and *Streptococcus* species, which play a role in the fermentation of dairy and vegetable products.

Oxygen availability

Some of the fermentative bacteria are anaerobes, while others require oxygen for their metabolic activities. Some, lactobacilli in particular, are microaerophilic. That is they grow in the presence of reduced amounts of atmospheric oxygen. In aerobic fermentation's, the amount of oxygen present is one of the limiting factors. It determines the type and amount of biological product obtained, the amount of substrate consumed and the energy released from the reaction. Acetobacter require oxygen for the oxidation of alcohol to acetic acid.

Nutrients

All bacteria require a source of nutrients for metabolism. The fermentative bacteria require carbohydrates – either simple sugars such as glucose and fructose or complex carbohydrates such as starch or cellulose. The energy requirements of micro-organisms are very high. Limiting the amount of substrate available can check their growth.

Principles of lactic acid fermentation

Sauerkraut is one example of an acid fermentation of vegetables. The name sauerkraut literally translates as acid cabbage. The 'sauerkraut process' can be applied to any other suitable type of vegetable product. Because of the importance of this product in the German diet, the process has received substantial research in order to commercialise and standardise production. As a result, the process and the contributing micro-organisms are known intimately. Other less well known fermented fruits and vegetables have received less research attention, therefore little is known of the exact process. It is safe to assume however that the acid fermentation of vegetables is based on this process.

Lactic acid fermentation's are carried out under three basic types of condition:– dry salted, brined and non-salted. Salting provides a suitable environment for lactic acid bacteria to grow which impart the acid flavour to the vegetable.

Salt for pickling.

For pickling any variety of common salt is suitable as long as it is pure. Impurities or additives can cause problems. Salt with chemicals to reduce caking should not be used as they make the brine cloudy. Salt with lime impurities can reduce the acidity of the final product and reduce the shelf life of the product. Salt with iron impurities can result in the blackening of the vegetables. Magnesium impurities impart a bitter taste. Carbonates can result in pickles with a soft texture.

Dry salted fermented vegetables

With dry salting, the vegetable is treated with dry salt. The salt extracts the juice from the vegetable and creates the brine. The vegetable is prepared, washed in potable cold water and drained. For every 100kg of vegetables 3 kg of salt is needed. The vegetables are placed in a layer of about 2.5cm depth in the fermenting container (a barrel or keg). Salt is sprinkled over the vegetables. Another layer of vegetables is added and more salt added. This carries on until the container is three quarters full. A cloth is placed above the vegetables and a weight added to compress the vegetables down to assist the formation of a brine. The formation of a brine takes about 24 hours. As soon as the brine is formed, fermentation starts. As fermentation starts, bubbles of carbon dioxide appear. Fermentation takes between one and four weeks depending on the ambient temperature. Fermentation is complete when no more bubbles appear, after which time the pickle can be packaged in a variety of mixtures, including vinegar and spices or oil and spices.

The 'sauerkraut' process.

Shredded cabbage or other suitable vegetable is placed in a jar and salt added. Mechanical pressure is applied to the cabbage to expel the juice, which contains fermentable sugars and other nutrients suitable for microbial activity. The first micro-organisms to start acting are the gas-producing cocci *(L. Mesenteroides)*. These microbes produce acids. When the acidity reaches 0.25 to 0.3% (calculated as lactic acid), these bacteria slow down and begin to die off, although their enzymes continue to function. The activity initiated by the *L. mesenteroides* is continued by the lactobacilli *(L. plantarum and L. Cucumeris)* until the acidity reaches 1.5 to 2%. The high salt concentration and low temperature inhibit these bacteria to some extent. Finally, *L. pentoaceticus* continue the fermentation, bringing the acidity to 2 to 2.5% which completes the fermentation.

The end products of a normal kraut fermentation are chiefly lactic acid plus smaller amounts of acetic and propionic acids, a mixture of gases of which carbon dioxide is the principal one small amounts of alcohol and a mixture of aromatic esters. The acids, in combination with alcohol form esters, which contribute to the characteristic flavour of sauerkraut. The acidity helps to control the growth of spoilage and putrefactive organisms and contributes to the extended shelf life of the product. Changes in the sequence of desirable bacteria, or indeed the presence of non-desirable bacteria, will result in alterations to the taste and quality of the product.

Effects of temperature on sauerkraut process

The optimum temperature for sauerkraut fermentation is around 21°C. A variation of just a few degrees from this temperature alters the activity of the microbial process and affects the quality of the final product. Therefore, temperature control is one of the most important factors in the sauerkraut process. A temperature of 18° to 22° C is the most desirable for initiating fermentation since this is the optimum temperature range of *L. mesenteroides*. Temperatures above 22°C favour the growth of *Lactobacillus* species.

Effects of salt on sauerkraut process

Salt plays an important role in initiating the sauerkraut process and affects the quality of the final product. The addition of too much salt may inhibit the desirable bacteria, although it may contribute to the firmness of the kraut The principle function of salt is to withdraw juice from the cabbage (or other vegetable), so making a more favourable environment for the desired bacteria to develop.

Generally, salt is added to give a concentration of 2.0 to 2.5%. At this concentration, the lactobacilli are slightly inhibited, but the cocci are not affected. Unfortunately, this concentration of salt has a greater inhibitory effect against the desirable organisms than against those responsible for spoilage. The spoilage organisms can tolerate salt concentrations up to 5 to 7%, therefore it is the acidic environment created by the lactobacilli that keep the spoilage bacteria at bay, rather than the addition of salt.

In the manufacture of sauerkraut, dry salt is added at the rate if 1 to 1.5kg per 50kg cabbage (2 to 3%). The use of salt brines is not recommended in sauerkraut making, but is common in vegetables that have a low water content. It is essential to use pure salt since salts with added alkali may neutralise the acid.

Use of starter cultures

In order to produce sauerkraut of consistent quality, starter cultures (similar to those used in the dairy industry) have been recommended. Not only do starter cultures ensure consistency between batches, they speed up the fermentation process as there is no time lag while the relevant microflora colonise the sample. Because the starter cultures used are acidic, they also inhibit the undesirable micro-organisms. It is possible to add starters traditionally used for milk fermentation, such as *Streptococcus lactis*, without adverse effect on final quality. Because these organisms only survive for a short time (long enough to initiate the acidification process) in the kraut medium, they do not disturb the natural sequence of micro-organisms.

It is possible to use the juice from a previous kraut fermentation as a starter culture for subsequent fermentation's.

Spoilage and defects in the sauerkraut process.

The majority of spoilage in sauerkraut is due to aerobic soil micro-organisms which break down the protein and produce undesirable flavour and texture changes. The growth of these aerobes can easily be inhibited by a normal fermentation.

Soft kraut can result from many conditions such as large amounts of air, poor salting procedure and varying temperatures. Whenever the normal sequence of bacterial growth is altered or disturbed, it usually results in a soft product. It is the lactobacilli, which seem to have a greater ability than the cocci to break down cabbage tissues, which are responsible for the softening. High temperatures and a reduced salt content favour the growth of lactobacilli, which are sensitive to higher concentrations of salt. The usual concentration of salt used in sauerkraut production slightly inhibits the lactobacilli, but has no effect on the cocci. If the salt content is too low initially, the lactobacilli grow too rapidly at the beginning and upset the normal sequence of fermentation.

Another problem encountered is the production of dark coloured sauerkraut. This is caused by spoilage organisms during the fermentation process. Several conditions favour the growth of spoilage organisms. For example, an uneven distribution of salt tends to inhibit the desirable organisms while at the same time allowing the undesirable salt tolerant organisms to flourish. An insufficient level of juice to cover the kraut during the fermentation allows undesirable aerobic bacteria and yeast's to grow on the surface of the kraut, causing off flavours and discoloration. If the fermentation temperature is too high, this also encourages the growth of undesirable microflora, which results in a darkened colour.

Pink kraut is a spoilage problem. It is caused by a group of yeast's which produce an intense red pigment in the juice and on the surface of the cabbage. It is caused by an uneven distribution of or an excessive concentration of salt, both of which allow the yeast to multiply. If conditions are optimal for normal fermentation, these spoilage yeast's are suppressed.

Brine salted fermented vegetables

Brine is used for vegetables which inherently contain less moisture. A brine solution is prepared by dissolving salt in water (a 15 to 20% salt solution). Fermentation takes place well in a brine of about 20 salometer. As a general guide, a fresh egg floats in a 10% brine solution. Properly brined vegetables will keep well in vinegar for a long time. The duration of brining is important for the overall keeping qualities. The vegetable is immersed in the brine and allowed to ferment. The strong brine solution draws sugar and water out of the vegetable, which decreases the salt concentration. It is crucial that the salt concentration does not fall below 12%, otherwise conditions do not allow for fermentation. To achieve this, extra salt is added periodically to the brine mixture.

Once the vegetables have been brined and the container sealed, there is a rapid development of micro-organisms in the brine. The natural controls which affect the microbial populations of the fermenting vegetables include the concentration of salt and temperature of the brine, the availability of fermentable materials and the numbers and types of micro-organisms present at the start of fermentation. The rapidity of the fermentation is correlated with the concentration of salt in the brine and its temperature.

Brine salted fermentation of vegetables (Pickles)

Pickled cucumbers are another fermented product that has been studied in detail and the process is known. The fermentation process is very similar to the sauerkraut process, only brine is used instead of dry salt. The washed cucumbers are placed in large tanks and salt brine (15 to 20%) is added. The cucumbers are submerged in the brine, ensuring that none float on the surface - this is essential to prevent spoilage. The strong brine draws the sugar and water out of the cucumbers, which simultaneously reduces the salinity of the solution. In order to maintain a salt solution so that fermentation can take place, more salt has to be added to the brine solution. If the concentration of salt falls below 12%, it will result in spoilage of the pickles through putrefaction and softening.

A few days after the cucumbers have been placed in the brine, the fermentation process begins. The process generates heat which causes the brine to boil rapidly. Acids are also produced as a result of the fermentation.

During fermentation, visible changes take place which are important in judging the progress of the process. The colour of the cucumber surface changes from bright green to a dark olive green as acids interact with the chlorophyll. The interior of the cucumber changes from white to a waxy translucent shade as air is forced out of the cells. The specific gravity of the cucumbers also increases as a result of the gradual absorption of salt and they begin to sink in the brine rather than floating on the surface.

Problems in pickles

If too much acid is produced during the fermentation it tends to shrivel the pickles. This may be because of over-activity of the *L. mesenteroides* species. If the brine is stirred, it may introduce air, which makes conditions more favourable for the growth of spoilage bacteria. In general, if the pickles are well covered with brine, the salt concentration is maintained and the temperature is at an optimum, it should be quite simple to produce good quality pickles.

Dry salted pickles

Dry salting method is used for pickling many vegetables and fruits including limes, lemons and cucumbers. For dry salt pickling any variety of common salt is suitable as long as it is pure. Impurities or additives can cause problems:

- Chemicals to reduce caking should not be used as they make the brine cloudy.
- Lime impurities can reduce the acidity of the final product and reduce the shelf life of the product.
- Iron impurities can result in the blackening of the vegetables.
- Magnesium impurities impart a bitter taste.
- Carbonates can result in pickles with a soft texture.

Dry salted lime pickle.

Dry salted lime pickles are produced in Asia and Africa. They are particularly popular in India, Pakistan and North Africa.

The limes are treated with dry salt. The salt extracts the juice from the vegetable and creates the brine. The final product is a sour lime pickle. Spices are added depending on local preference. In India and Pakistan, the pickle is usually very spicy and hot due to the chilli added. It is usually eaten as a condiment.

Raw materials

4kg limes
1kg salt
Spices - optional

Preparation

The limes need to be selected and prepared. Only fully ripe limes without bruising or damage should be used. All the limes need to be washed in potable cold water and drained. Each lime is then cut into quarters or four slits made on the skin. All spices should be of good quality and free of mould.

Processing

The limes are placed in a layer of about 2.5cm depth in the fermenting container (a barrel or keg). One kilogram of salt is added for every four kilogram of limes. The salt is sprinkled over the vegetables. Another layer of vegetables is added and more salt added. This carries on until the container is three quarters full. A cloth is placed above the vegetables and a weight added to compress the vegetables down to assist the formation of a brine. The formation of a brine takes about 24 hours. The container is then placed in the sun for a week. As soon as the brine is formed, fermentation starts. As fermentation starts bubbles of carbon dioxide appear. Fermentation takes between one and four weeks depending on the ambient temperature. Fermentation is complete when no more bubbles appear.

Process	*Quality control notes*
Selection ↓	Only ripe limes should be selected
Wash ↓	In clean water
Cut ↓	Cut into four pieces or slice the skin
Mix with salt ↓	1kg salt for 4kg of limes
Ferment ↓	Leave the container in the sun for a week to ferment
Package	

Packaging and storage

The pickle can now be packaged. The vegetables can be removed from the brine and packaged in a variety of mixtures. These can be vinegar and spices or oil and spices. Lime pickle can be packed in small polythene bags and sealed or in clean jars and capped. Lime pickle keeps well if stored in a cool place. Due to the high acid level of the final product, the risk of food poisoning is low.

Brined fruit and vegetable pickles

Brined pickles are made using a brine solution rather than dry salt.

Green Mango Pickle.

Mango pickle is a very popular pickle in many Asian, African and Latin American countries. It is a major product of India, Pakistan and Bangladesh and it is estimated that the annual production of mango pickle in South Africa is over 10,000 tons.

Green mango pickle is a hot, spicy pickle with a sour taste. It is eaten as a condiment. Preservation is caused by a combination of salt, increased acidity and to a small extent the spices.

Raw material preparation

Mangoes
Brine solution (20% salt solution)
Spices

The fresh, fully mature, firm but unripe mangoes must be carefully selected to ensure a good quality product. The best pickles are obtained from fruit at early maturity when the fruit has reached almost maximum size. Riper fruit results in pickles with a fruity odour and lacking the characteristic and predominant green mango flavour.

The green mangoes need to be inspected and any damaged fruit rejected. The fruit is washed in clean water and drained.

After draining, the fruit is cut. Sharp knives with preferably stainless blades should be used. Iron or copper equipment should be avoided. A single stroke should be used during the cutting process to ensure minimum damage and avoiding mushiness in the final product.

Processing

The sliced mangoes need to be soaked in brine solution. Sodium metabisulphite (1000 ppm) and 1% calcium chloride can be added. The containers are stored until the mangoes are pickled. The brine is then drained off and spices are mixed with the mango slices.

Process	*Quality control notes*
Fruit	The mangoes need to be unripe
↓	
Sort	Remove damaged fruit
↓	
Wash	With clean water.
↓	
Drain	
↓	
Cut	Stainless steel knives should be used
↓	
Soaked in brine	20% salt solution
↓	
Drain	
↓	
Add spices	Spices to taste
↓	
Pack	Pack in containers and add oil

Packaging and storage

The mixture is then packed and oil added onto the surface of the mixture. The mangoes should be firmly pressed down in the container. Good quality vegetable oil such as sunflower oil should be used and finely ground chilli powder can be added to the oil for flavour and colour. Mango pickle can be packed in small polythene bags and sealed or in clean jars and capped. Mango pickle keeps well if stored in a cool place. If it is processed well, it can be kept for several months.

Lime pickle (brined).

This is an alternative method of producing the lime pickle described above.

Product description

Lime pickle is made from salted pieces of lime packed in a salty, spicy liquor, like a semi-solid gravy. It is brownish red and the lime peels are yellow or pale green with a sour and salty taste. It is eaten as a condiment with curries or other main meals. If processed well, the product can be kept for several months.

Raw material preparation

The limes need to be selected and prepared. Only fully ripe limes without bruising or damage should be used. All the limes need to be washed in potable cold water and drained. The limes are dipped in hot water (60-65^{0}C) for about five minutes. The limes are then cut into pieces to expose the interior and allow salt to be absorbed more quickly.

All spices should be of good quality and free of mould.

Processing

The prepared limes are covered with a brine solution. This causes water to be drawn out of the pieces by osmosis. It is important to ensure that the surface is covered with juice, and leave for 24 hours. If necessary, the fruits should be pressed down to hold them below the liquid. Once the limes have been placed in the brine, there is a rapid development of micro-organisms and fermentation begins.

After fermentation the limes are dried in the sun until the skin becomes brown.

Process	*Quality control notes*
Sort ↓	Select ripe (but not overripe) healthy lime fruits.
Wash ↓	
Heat ↓	Dip in hot water (60-65^{0}C) for about five minutes.
Cut ↑	Cut into four pieces or alternatively cut into smaller, uniform-sized pieces.
Brine ↓	Ensure that the surface is covered with juice.
Dry ↓	Dry in the sun for 2-3 days.
Mix spices ↓	To local preference
Pack ↓	
Store	In a cool place, away from sunlight.

Packaging and storage

The limes are mixed with spices and oils according to local taste and tradition. Lime pickle can be packed in small polythene bags and sealed or in clean jars and capped. Lime pickle keeps well if stored in a cool place. Due to the high acid level of the final product, the risk of food poisoning is low.

Non salted pickled products

Gundruk (pickled leafy vegetable)

Gundruk is particularly popular in Nepal. The annual production of *gundruk* in Nepal is estimated at 2,000 tons and most of the production is carried out at the household level.

Gundruk is obtained from the fermentation of leafy vegetables in Nepal. It is served as a side dish with the main meal and is also used as an appetiser. *Gundruk* is an important source of minerals particularly during the off-season when the diet consists of mostly starchy tubers and maize which tend to be low in minerals

Raw materials

Green leaves

Processing

The shredded leaves are tightly packed in an earthenware pot and warm water (at about 30°C) is added to cover all the leaves. The pot is then kept in a warm place. After five to seven days, a mild acidic taste indicates the end of fermentation and the *gundruk* is removed and sun-dried. This process is similar to sauerkraut production except that no salt is added to the shredded leaves before the start of *gundruk* fermentation. The ambient temperature at the time of fermentation is about 18°C.

Process	*Quality control notes*
Leafy vegetables	
↓	
Wilt	One to two days
↓	
Shred	
↓	
Placed in earthen pot	The leaves need to tightly packed
↓	
Cover the leaves	Cover the leaves with warm water and straw
↓	
Ferment	The pot is kept warm in the sun and by a fire by night.
↓	
Add warm water	To keep the pot warm
↓	
Dried	Product dried on mats in the sun

Fruit and vegetables pickled in vinegar

Pickled vegetables, are produced by adding a mixture of salt and vinegar to prepared vegetables. The following is a method for producing atchar – a hot and spicy vegetable pickle commonly consumed in Asia. Variations of vegetables can be used according to preference and local availability.

Equipment needed

Mixing bowl
Boiling pan (stainless steel)
Grater
Heat sealer or jar capper
Jar filler
Weighing scales

Raw materials

750g carrots
600g cabbage
100g green pepper (capsicum)
450g onions
120g cayenne pepper
15g ginger powder
40g salt
30g curry powder
750ml sunflower oil
300ml vinegar

Method

Selected vegetables are chopped to a uniform size. They are lightly cooked and mixed together with a blend of spices (according to taste and preference), salt and vinegar. The salt and vinegar act as preservatives and it is essential that the ratio of these two ingredients is controlled to prevent spoilage through fermentation or mould growth. The final level of acetic acid should be 6 to 10%.

Process	*Quality control notes*
Select raw material ↓	use **firm, undamaged** vegetables
Wash ↓	in clean water
Peel and cut ↓	peel carrots and onions, chop these and the peppers into small pieces
Grate ↓	carrots to fine shreds
Mix ingredients ↓	mix spices and salt together
Heat spices ↓	heat dry spices in a little sunflower oil (about 50ml)
Add onions ↓	fry onions in spicy oil at 150°C until soft (about 5 mins)
Add oil and vinegar ↓	add 700ml oil and the vinegar to the fried onions. **Mix well**

Mix cabbage, heat ↓	add cabbage and cook for about 5 minutes
Mix carrots and pepper ↓	heat for about 5 minutes with stirring
Pack ↓	hot-fill into pre-sterilised glass jars or polypropylene bags
Seal ↓	seal on caps or heat seal bags
Label ↓	with the name of product, name of producer, sell by date and list of ingredients
Store	in a cool dry place, away from sunlight.

TOMATO SAUCE/KETCHUP

Tomato sauce or ketchup is a condiment produced mainly from tomatoes, with added spices and flavouring. It is preserved by a combination of acidity and reduction in the free water content and by packaging in sealed containers.

Equipment required

Pulper
Boiling pans (stainless steel)
Tilting pan
Refractometer
Thermometer
Washing tank
Bottle filler
Capper
Weighing scales
Bottle steriliser

Raw materials

20 kg tomatoes
1.5 kg sugar
450 g onions, finely chopped
330g salt
800g vinegar
*spices**

- 3.5g mace
- 9g cinnamon
- 11.25g cardamom
- 11.25g cumin
- 11.25g ground black pepper
- 5g ground white pepper
- 5g ground ginger

Note
Tomatoes should be fully ripe, not damaged or bruised.
Spices should be clean, mature and free from mould or insect infestation.
* The spices should be chosen according to local availability and taste preference. A tomato chilli sauce, which is popular in many countries, can be prepared by adding 2.5g chilli powder to 10kg tomato pulp before processing.

Whatever the choice of spices to add to the basic sauce ingredients (tomato, onion, sugar, salt and vinegar), it is essential that the ratio of ingredients is carefully monitored and controlled from batch to batch to ensure sauce/ketchup of a consistent taste, flavour and consistency.

The product must be stirred continuously during heating to prevent burning

The end of boiling is determined by checking the total soluble solids content with a refractometer. This should be 10 to 12 %.

If adequately packaged and stored in a cool place, the sauce can be stored for up to a year, without any loss of flavour or taste. However, it should be stored out of direct sunlight to avoid any discoloration.

Method

Process	*Quality control notes*
Sort tomatoes ↓	select **good quality**, fully ripe red fruits without infection, mould or rot
Wash ↓	use clean water
Heat ↓	**blanch** in hot water for 3-5 minutes until the skin is loosened
Cool ↓	**cool** immediately in clean, cold water
Peel ↓	remove skin and core
Pulp ↓	chop and pulp, either by hand grinder or using a pulper, depending upon the size of operation
Mix ingredients ↓	tie the spices in a small muslin bag, add to the tomatoes with 500g sugar and the chopped onions
Heat ↓	heat to below boiling point in a heavy pan with **continuous stirring** until it has reduced to half the original volume
Separate ↓	remove the spice bag
Mix ingredients ↓	add 1kg sugar, salt and vinegar.
Heat ↓	continue heating for 5-10 minutes. Check the **final total soluble solids** with a refractometer (should be 10-12% solids)
Fill ↓	**hot-fill** into pre-sterilised bottles or jars at not less than 80°C
Seal ↓	close the lids tightly
Cool ↓	**cool** to room temperature
Label ↓	add product name, date of manufacture, contents, brand name, name of manufacturer
Store	store away from sunlight in a cool place

FRUIT JUICES

Fruit juices are made from pure filtered fruit with nothing added. In some places, sodium benzoate is added as a preservative to extend the shelf life after opening, but this is not essential. Any fruit can be used to produce juice, but common ones include pineapple, orange, grapefruit, passion fruit and mango.

Some fruit juices are not filtered after pulping – these are known as fruit nectars. Guava is commonly used to produce a fruit nectar. The nectar is made according to the same method as the fruit juice, but omitting the filtering stage.

Fruit juices rely on a combination of acidity, pasteurisation and packaging in sealed containers for their preservation. They have to be drunk immediately after opening. If care is taken over the packaging, pasteurised juices can be stored in a cool dark place for up to a year. It is normal for some sediment to form at the bottom of the bottle as it is left to stand, but if this is excessive, a finer filter can be used.

Equipment required

Juice extractor
Filter (bags)
Filter unit
Boiling water bath
Capper
Bottle filler
Bottle steriliser
Pasteuriser

Raw materials

Good quality ripe fruit, free from blemishes and mould.

Method

Process	*Quality control notes*
Sort fruit ↓	discard any mouldy or under-ripe fruits
Wash ↓	use clean water
Cut ↓	halve fruits – using stainless steel knives to avoid discoloration
Press ↓	using hand operated juice extractor or mechanical extractor, depending upon scale of operation
Separate ↓	**filter** juice to remove pieces of pulp
Fill and seal ↓	into **pre-sterilised** bottles and **seal**
Heat ↓	**pasteurise** bottles in a boiling water bath for 8 to 10 minutes, depending upon the size of bottles
Cool ↓	rapidly to room temperature by placing bottle in cold water
Label ↓	add product name, date of manufacture, contents, brand name, name of manufacturer
Store	in a **cool** place away from direct sunlight

JAMS

Jams and jellies are prepared from a mixture of fruit or fruit juice, sugar and pectin. Various combinations of fruit and sugar are used, with the minimum fruit content being 40%. The jam can be made from a single fruit or from a mixture of fruits available. Pectin is added to the mixture to help with setting. Some fruits are high in pectin, but others, such as strawberry, need pectin added –either from a commercial source of pectin or from a fruit that is naturally high in pectin – eg apple.

The total sugar content (final soluble solids) of the jam should not be less that 68% to prevent mould growth after opening the jar.

The principles of preservation involve heating to destroy the enzymes and micro-organisms, combined with a high acidity and sugar content to prevent the re-growth of microbes.

Jam is a solid gel produced from fruit pulp or juice, sugar and pectin whereas a jelly is a crystal clear gel produced from filtered juice rather than pulp.

Equipment needed

Juices
Juice extractor
Filter (bags)
Filter unit
Boiling water bath
Capper
Bottle filler
Bottle steriliser
Pasteuriser

Jams/jellies
Juice extractor
Peeler
Sieve
Straining bag/equipment
Scales
Refractometer
Boiling pans (stainless steel)
Tilting pan
Thermometer
Solid filler
Sealing machine
Label gummer

Raw materials

Fruit }
Sugar }equal amounts
Pectin approx 3% of weight
Citric acid – (to reduce pH to 3.0 – 3.3)

The proportions of these ingredients varies according to the type of fruit used, but mus tbe consistent between different batches of the same product.

The main quality control points to be aware of are as follows:

Fruit selection:
all fruit should be ripe and free from bruising or insect damage and mould. It should be well washed and peeled and stoned before use.

Ingredient mixing:
accurate scales are required to ensure that the correct weights are used each time. This is particularly so for the pectin powder, which has to be mixed with sugar before it is added to prevent lumps from forming. Two sets of weighing scale will be required - one with a large capacity for the bulky ingredients and a smaller set capable of weighing grammes rather than kilogrammes.

Acidity:
acid (usually citric acid, but also hydrochloric acid, tartaric acid or malic acid) is added to the jam to ensure that the pH is in the range 3.0 to 3.3. This level of acidity is required to enable the pectin to form a set gel. It is also an essential part of the preservation process, making the final product resistant to damage from mould and bacterial growth.

Sugar
Refined granular sugar should be used whenever possible to produce a high quality preserve. Often this type of sugar contains small impurities that can spoil the final quality of the product. Therefore it is advisable to dissolve the sugar in water to produce a strong syrup that is filtered through a fine mesh prior to use. The strength of the syrup can easily be calculated according to the following equation:

$$\%sugar(Brix) = \frac{weightsugar}{weightsugar + weightwater} * 100$$

Pectin

All fruits contain pectin in the skins and to a lesser extent in the pulp. However, the amount of pectin varies with variety and with the maturity of the fruit. Apples, citrus peel and passion fruit contain a high concentration of pectin, whereas strawberries and melon contain less.

Although it is possible to get a good preserve using the pectin already in the fruit, it is better to buy a pectin powder or solution and add a known amount to the fruit juice or pulp. This will produce a standardised gel each time.

There are different types of pectin available – fast setting and slow setting types. The slow setting types are necessary for preserves that are left to cool and set in the jars. Fast setting types are needed for larger containers or for preserves that contain suspended pieces of fruit or fruit peel. The concentration of pectin used for each varies from 0.2 to 0.7% depending upon the type of fruit being used. Pectin is usually supplied as 150 grade (or 150 SAG) which indicates the ratio of the weight of sugar to pectin needed to obtain a standard gel at 65% soluble solids.

5 SAG is normally enough to produce a good gel, thus the 150 SAG pectin needs to be diluted 30 times to produce a 5 SAG strength. Therefore, 3.3g 150 SAG pectin would be used for every 100g of sugar.

If commercial pectin is not available, it is possible to produce a pectin solution by boiling the sliced skins of passion fruit or citrus fruit in water for 20 to 30 minutes. The solution should be filtered before it is added to the fruit pulp. The amount needed depends on the type of fruit and the concentration of the pectin solution and can only be found by trial and error.

Method – Jam production

Process	*Quality control notes*
Prepare raw material ↓	select **mature, undamaged** fruit
Peel, stone and chop ↓	remove all peel, stems, seeds and stones as necessary; roughly chop the fruit
Add ingredients ↓	**accurately weigh** and add sugar (syrup), pectin and citric acid. Check the **pH (3.0 to 3.3)**
Heat ↓	initially the mixture should be **heated slowly** to soften the fruit and release the juices and pectin. It is then **boiled rapidly**, taking care to avoid localised heating and burning. Boiling is continued until the **final total sugar content is reached (68%)**. This is tested using a refractometer.
Fill ↓	Jam is **hot filled** into clean pre-sterilised jars and sealed with a lid. The ideal temperature for pouring is 82-85C – hotter than this and condensation will form on the lid, which is a potential source of spoilage. Colder than this the jam will begin to set and will be difficult to pour. Jars should be filled to about 9/10ths of their volume.
Cool ↓	**cool** to room temperature
Label ↓	add product name, date of manufacture, contents, brand name, name of manufacturer
Store	store away from sunlight in a cool place.

Method – Jelly production

Process	*Quality control notes*
Prepare raw material ↓	select **mature, undamaged** fruit
Peel, stone and chop ↓	remove all peel, stems, seeds and stones as necessary; roughly chop the fruit
Pulp ↓	using a steamer, reamer or by pressing or pulping depending upon the type of fruit and scale of operation
Filter ↓	the pulp using a muslin cloth (jelly bag) to obtain a clear liquid. Also filter the syrup solution to remove impurities
Add ingredients ↓	**accurately weigh** and add sugar (syrup), pectin and citric acid. Check the **pH (3.0 to 3.3)**
Heat ↓	initially the mixture should be **heated slowly** to soften the fruit and release the juices and pectin. It is then **boiled rapidly**, taking care to avoid localised heating and burning. Boiling is continued until the **final total sugar content is reached (68%)**. This is tested using a refractometer.
Fill ↓	Jelly is **hot filled** into clean pre-sterilised jars and sealed with a lid. The ideal temperature for pouring is 82-85C – hotter than this and condensation will form on the lid, which is a potential source of spoilage. Colder than this the jam will begin to set and will be difficult to pour. Jars should be filled to about 9/10ths of their volume.
Cool ↓	**cool** to room temperature
Label ↓	add product name, date of manufacture, contents, brand name, name of manufacturer
Store	store away from sunlight in a cool place.

Properly sealed and packaged in sterile containers, jams and jellies can be stored in a cool place for up to a year.