UNIDO TECHNOLOGY MANUAL

Small-scale Fruit and Vegetable Processing and Products

Production methods, equipment and quality assurance practices

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION

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Production Methods, Equipment and Quality Assurance Practices

UNITED NATIONS INDUSTRIAL DEVELOPMENT ORGANIZATION
Vienna, 2004

First published 2004

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Preface

UNIDO has emphasized micro/small-scale business development it its technical assistance programmes as a means to contribute to economic growth and poverty reduction in Africa in general and Uganda in particular. This technology manual is an important tool that contributes to the capacity building activities carried out by UNIDO in the small-scale food processing sector within the framework of the UNIDO Uganda Integrated Programme: Enhanced Competitiveness and Sustainability of Industrial Development - Agro-industries and Micro/Small-scale Enterprises.

The purpose of this manual is to guide small-scale processors in the Ugandan fruits and vegetables sector to optimize their processing methods and implement quality assurance schemes and GHP (Good Hygienic Practices) and GMP (Good Manufacturing Practices) programmes thus building their technical capacity for improved market access and competitiveness. In general, fruit and vegetable processing offers good opportunities for small-scale businesses in Uganda. This is because:

- Raw materials are readily available (often in surplus)
- Most equipment is reasonably affordable and
- The products, if chosen correctly, have a good demand and can be profitable.

Processing fruits and vegetables is intended to do two things:

1. To preserve them by slowing down the natural processes of decay caused by micro-organisms, enzymes in the food, or other factors such as heat, moisture and sunlight.
2. To change them into different foods, which are attractive and in demand by consumers. Like chefs and caterers, processors should use their skills to develop attractive recipes and make products that consumers want to eat. By doing this successfully, they can increase sales and earn an income.

Processors must choose their products very carefully. It is not enough to assume that processing can be a successful business simply because there is plenty of cheap fruit available. There must be a good demand for the processed food and this must be clearly identified before a business is set up. The best types of products for small-scale production are those that have a high ‘added-value’ as well as a good demand. A high added value means that cheap raw materials can be processed into relatively expensive products. It also means that this can be done at a small scale of processing using equipment that is affordable.

Small-scale fruit and vegetable processors have many competitors in Uganda as well as competing with imported products. To be profitable, it is therefore essential to have good quality products, attractive packaging and a well-managed business. To successfully compete, a business should do everything it can to make products at competitive prices and develop new ones that they are different to those of competitors.

This technology manual covers the technical aspects of fruit and vegetable processing but does not deal with the many other aspects of operating a successful small business (such as marketing, business and financial planning and management skills). Institutions listed in Annex A can provide more information on these topics. They are also covered in training courses organised by the Uganda Cottage Scale Food Processors Association (UCOFPA) under the UNIDO Uganda Integrated Programme: Enhanced Competitiveness and Sustainability of Industrial Development - Agro-industries and Micro/Small Scale Enterprises.

Together with GHP, GMP and proper management, processors (and retailers) should be aware of new laws that are coming in Uganda that relate to food safety. These are based on standards produced by an organisation known as the “Codex Alimentarius Commission” and they apply internationally. Some manufacturers of processed fruits and vegetables already export their products from Uganda. In this case Codex standards are already in force and producers should consult with the Bureau of Standards to ensure compliance. The requirements of new food safety laws can be met using good manufacturing and hygienic practices, and a technique known as the Hazard Analysis Critical Control Point (HACCP) system. There procedures will eventually apply to all manufacturers in Uganda, whether they export or not. Details of quality assurance methods that will enable manufacturers to produce safe foods are given in this manual, and further information on HACCP is available from the Bureau of Standards.

The facilities needed for commercial fruit and vegetable processing are described in Section 2. Production planning techniques and processing methods for fruit and vegetable products that are popular in Uganda are described in Sections 3 and 4. Details of the service and maintenance requirements of processing equipment are given in Section 5. Quality assurance methods are referenced in every section and summarized in Section 6. There is additional information on international and domestic food safety regulations, laws and standards in Section 7.

How to use this manual

The information contained in this Technology Manual is intended to serve three purposes:

1. It is a resource for trainers who work with small scale fruit and vegetable processing entrepreneurs at Pilot Centres established under the UNIDO Enhanced Competitiveness and Sustainability of Industrial Development - Agro-industries and Micro/Small Scale Enterprises Programme and
2. It is a reference manual to assist these entrepreneurs to continue to improve the technical aspects of their businesses after training.
3. It is a reference manual that outlines practices and procedures for the production of safe, high quality fruit and vegetable-based processed products and for development of Good Hygienic Practices (GHP) and Good Manufacturing Practices (GMP) programmes that will serve as the foundation for the preparation of a Hazard Analysis and Critical Control Point (HACCP) system.

Where appropriate, there are worked examples of calculations to assist entrepreneurs to develop their skills, particularly in production planning. Throughout the text there are also checklists of important points to enable processors to assess their present quality and food safety practices. This will assist the processors and producers to identify where production, processing, hygiene and food safety improvements are needed.

Contents

1 Introduction

Although there are many similarities between fruits and vegetables, there is one important difference that affects the way that these two types of crop are processed:

Most fruits are more acidic than most vegetables!

This is important because food poisoning bacteria cannot grow in more acidic fruit products. Even if a processor makes a mistake in processing, fruit products cannot cause food poisoning. If the mistake allows moulds and yeasts to grow, they produce obvious signs of spoilage, which stops consumers eating the food. If a contaminated product is eaten, yeasts and moulds rarely cause food poisoning.

Table 1.1. Different levels of acidity in fruits

Very acidic fruits pH<3.7	Moderately Acidic fruits pH3.7-4.5	Less acidic fruits pH >4.5
Grapefruit	Guava	Banana
Lemon	Mango	Breadfruit
Lime	Passion fruit	Melon
Orange	Pineapple	Papaya
Tamarind	Strawberry	Squash
Tangerine	Tomato	

(Assuming all fruits are fully ripe, from 'The Composition of Foods', Paul, A.A. and Southgate, D.A.T., Elsevier, 1985)

Vegetables are less acidic than fruits and food poisoning bacteria are able to grow in many vegetable products. Some types of bacteria produce poisons in the food without signs of spoilage and consumers may be unaware of the contamination and eat the poisoned food. It is therefore especially important that vegetable processors carefully follow the correct processing methods and pay strict attention to hygiene and sanitation to reduce the risk of harming their customers.

Characteristics of fruits and vegetables

After harvest, micro-organisms and naturally occurring enzymes rapidly change the colour, flavour and texture of fruits and vegetables. The speed varies with different types of crop (Table 1.2), but, compared to other crops (such as cereals), there is a limited amount of time available before they must be processed. Other problems that face fruit and vegetable processors include:

- Most fruits and vegetables are seasonal. For a business to operate throughout the year, crops must be either part-processed for temporary storage, or a succession of crops must be processed as they come into season
- Raw materials have to be bought during a relatively short harvest period when prices are lowest. There is therefore the need to have sufficient cash available to buy a year's supply of crop.

Table 1.2. Time before spoilage starts in selected fruits and vegetables in Uganda

Time available between harvest and processing before spoilage begins		
A few days	**A few weeks**	**1-2 months**
Fruits	**Fruits**	**Fruits**
Banana (dessert)	Avocado	Gourd (bottle)
Cantaloupe melon	Banana (cooking)	Lemon
Guava	Breadfruit	Lime
Mango	Grapefruit	Orange
Papaya	Jackfruit	Tamarind
Passion fruit	**Vegetables**	Tangerine
Pineapple	Cabbage	**Vegetables**
Strawberry	Capsicum	None
Watermelon	Chickpea	
Vegetables	Cowpea	
Cauliflower	Lima bean/Navy bean	
Courgette	Pigeon pea	
Cucumber	Pumpkin	
Green bean	Soybean	
Leek	Squash	
Lettuce		
Okra		
Peppers		
Spinach		
Spring onion		
Tomato		

(Times depend on storage temperature and humidity and the amount of care taken in handling the crops after harvest. Data from author's field work)

Checklist 1

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.

Question	Tick	Notes
1. Do you know if your products are acidic?		
2. What types of spoilage can affect your products?		
3. Do you know how long your raw materials can be stored before they begin to spoil?		
4. Are you products safe from causing food poisoning?		
5. What are the main harvest times for your raw materials?		
6. Do you know how to part-process raw materials for temporary storage?		
7. Do you save money to buy a year's supply of crop at harvest or manage your cash flow to make funds available for buying crop?		
8. Do you have the organisational skills to process a succession of crops throughout the year?		

2 Production Facilities

This section summarises the facilities needed in a small fruit and vegetable processing unit. Further information is available in references in Annex A.

The Site

Because fresh fruits and vegetables are both bulky and spoil rapidly, it is better to locate a processing unit in the area where they are grown. This reduces transport costs and also reduces the amount of handling, which means that crops are more likely to be in good condition when they arrive at the processing unit. If they are in good condition, they can be stored for a few days before they have to be processed. Too much handling bruises them and they will spoil quickly. This increases the cost to the processor, because the spoiled food has already been paid for.

Processed fruit and vegetable products are likely to be sold in different markets and there is less reason to locate the unit near to customers (in contrast to bakeries for example). An ideal site is close to a fruit and vegetable growing area and near to a main road leading to an urban centre.

The location of the processing unit in a rural area means that there may be problems with:

- Reliable electricity
- Adequate supplies of potable water.
- Contamination of supplies
- Access for workers and staff (public transport, distance down an access road)
- Quality of the road (dry season only, potholes that may cause damage to glass containers)
- Absence of other facilities (e.g. schools, medical facilities, shops and entertainment) that make working there less attractive than an urban location

Each of these should be assessed before choosing a site. In rural locations there is usually more land available for waste disposal compared to urban sites, but there may be problems caused by insects and birds or straying animals getting into the building. It is therefore important to have a site with cleared and fenced land, preferably having short grass, which helps to trap airborne dust.

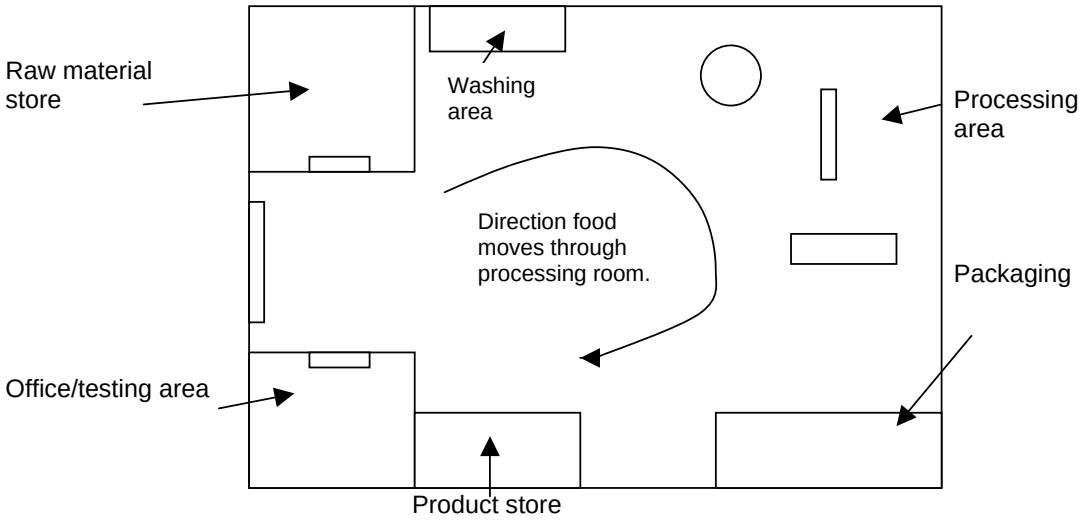
The building

All fruit and vegetable processing businesses should have a hygienically designed and easily cleaned building to prevent contamination of products. Buildings in rural areas may cost more to construct because of higher transport costs for building materials, but rents in rural areas are usually lower than urban centres. The investment in construction or the amount of rent paid should be appropriate to the size and expected profitability of the business.

Make sure that the building is big enough for your production, but do not pay for extra space that you do not need.

Within the building, food should move between different stages in a process without the paths crossing (Fig 2.1). This reduces the risk of contaminating finished products by incoming, often dirty, crops, as well as reducing the likelihood of accidents or of operators getting in each other's way. There should be enough space for separate storage of raw materials, away from ingredients, packaging materials and finished products.

Fig. 2.1. Basic design for a fruit and vegetable processing unit
(hand-washing/changing facilities and toilets in another building)



Roofs and ceilings

Overhanging roofs keep a building cooler, which is especially important when processing involves heat. Fibre-cement tiles provide greater insulation than galvanised iron sheets against heat from the sun. Roof vents allow heat and steam to escape and create a flow of fresh air through the processing room. The vents must be screened with mesh to keep insects and birds out of the room. If heat is a serious problem (e.g. jam boiling), electric fans or extractors can be used if they are affordable.

A panelled ceiling should be fitted in processing and storage rooms, rather than exposed roof beams, which allow dust to accumulate and fall off in lumps and contaminate products. Beams are also paths for rodents and birds, creating contamination risks from hairs, feathers or excreta. It is important to ensure that there are no holes in the panelling or in the roof and no gaps where the roof joins the walls, which would allow birds, rodents and insects to enter.

Walls, windows and doors

All internal walls should be plastered or rendered with concrete. The surface finish should have no cracks or ledges, which could harbour dirt or insects. The lower parts of the walls are most likely to get dirty from washing equipment, product splashing etc. They should either be tiled, or painted with waterproof white gloss paint to at least one and a half metres above the floor. Higher parts of walls and the ceiling can be painted with good quality white emulsion paint[1].

Natural daylight is preferable to and cheaper than, electric lighting in processing rooms. The number and size of windows depends on the amount of money that a processor wishes to invest and the security risk in a particular area (windows are more expensive than walls, especially when security bars or grilles are needed). Storerooms do not need to have windows. Open windows let in fresh air, but this also provides easy access for flying insects. All windows should therefore be screened with mosquito mesh. Windowsills should be made to slope to prevent dust accumulating and to prevent operators leaving cleaning cloths or other items lying there, which can attract insects.

Storeroom doors should not have gaps beneath them and should be kept closed to prevent insects and rodents from getting in and destroying stocks of product, ingredients or packaging materials. Processing room doors should be kept closed unless they are fitted with thin metal chains, or strips of plastic or cloth hung from door lintels. These keep out insects and birds, but allow easy access for staff. Alternatively, mesh door screens can be fitted.

Floors

Floors in processing rooms and storerooms should be made of good quality concrete, smooth finished and without holes or cracks. Over time, spillages of acidic fruit products react with concrete and erode it. Paints can protect floors, but vinyl-based floor paints are expensive. Red wax household floor polishes should not be used because they wear away easily and could contaminate products or spoil the appearance of packages. The best way to protect floors is to clean up spillages as they occur and make sure that the floor is thoroughly washed after each day's production.

Dirt can collect in corners where the floor and the walls join. To prevent this, the floor should be curved up to meet the wall. The floor should also slope to a drainage channel. Proper drainage prevents pools of stagnant water forming, which would allow insects to breed. The drainage channel should be fitted with metal gratings that are easily removed so that the drain can be cleaned. Rodents and crawling insects can also get into the building through the drain and a wire mesh cover should be fitted over the drain opening. This too should be easily removed for cleaning.

Services

Lighting and power

Where lighting is needed, florescent tubes use less electricity than light bulbs. Electric power points should be located at least one metre above the floor so that there is no risk of them getting wet when the floor and equipment is washed down. Ideally, waterproof sockets

[1] Details can be found in the Code of Practice for Hygiene in the Food and Drink Manufacturing Industry, US 28:2001/EAS.39, Section 12

should be used. Each power point should only be used for one machine. Multiple sockets should not be used because they risk overloading a circuit and causing a fire. All plugs should have fuses that are appropriate for the power rating of the equipment and the mains supply should have an earth leakage trip-switch. Cables should be properly fixed to walls or run vertically from the ceiling to machines. There should be no exposed wires at any connection. Electric motors should be fitted with separate starters and isolators.

Water supply and sanitation

Potable water is essential in all fruit and vegetable processing, as an ingredient in some products and for washing down equipment. An adequate supply of potable water should be available from taps in the processing room. If there is no mains supply, or if the mains supply is unreliable or contaminated, water from boreholes is likely to be relatively free from micro-organisms, but it may be contaminated with sand. River water is likely to be contaminated and should only be used if no other source is available.

Potable water is drinking water that is wholesome and clean and does not cause illness. It is free from any micro-organisms and parasites and from any substances, that in numbers and concentrations, constitute a potential danger to human health. It should meet standard US 201:1994 as established by UNBS.

Samples of water should be periodically checked (e.g. once per year) for contamination by micro-organisms at the Uganda Bureau of Standards, Makerere University Department of Food Science and Technology, UIRI, or one of the commercial testing laboratories in Kampala.

To remove sediment, two high level covered storage tanks should be installed, either in the roof-space or on pillars outside the building. They are filled when mains water is available or with water pumped from boreholes. While one tank is being used any sediment in water in the other tank settles out. The capacity of each tank should be enough for one day's production. The tanks should have sloping bases and be fitted with drain valves at the lowest point to flush out any sediment that has accumulated.

If necessary, water should be treated to remove micro-organisms. There are four ways of treating water at a small scale: by filtration; by heating; by ultra-violet light and by chemical sterilants, such as hypochlorite (also known as 'chlorine solution' or 'bleach'). Domestic water filters are too slow for the large amounts of water required and other water treatment methods are likely to be too expensive for small-scale producers.

Micro-organisms can also be destroyed by boiling water for 10-15 minutes, but this is not realistic for large volumes because of the high fuel costs and the time required to do this each day. Also, boiling does not remove sediment and boiled water may also need to be filtered. Ultra-violet light destroys micro-organisms in water and commercial treatment units are suitable for processors that use a lot of water. Again, this method does not remove sediment.

Dosing water with bleach is fast, cheap and effective against a wide range of micro-organisms. Water for cleaning should contain about 200 ppm of chlorine (by mixing 1 litre of

bleach into 250 litres of water). Water that is used as an ingredient should not contain more than 0.5 ppm chlorine (by adding 2.5 ml of bleach to 250 litres of water), to avoid contaminating products with a chlorine smell. Care is needed when using bleach because it damages the skin and particularly the eyes and can cause breathing difficulties if inhaled. It also corrodes aluminium equipment.

Equipment should be thoroughly cleaned after each day's production, using a cleaning routine that is clearly understood and followed by production workers (see Section 6, Quality Assurance). Solid wastes should be placed in bins and removed from the building at intervals, rather than letting them accumulate during the day. Wastes should never be left in a processing room overnight. Wastes should be taken far away from the processing site and either buried or turned into compost.

Large volumes of liquid wastes are created in fruit and vegetable processing and these should be carefully disposed of to prevent local pollution of streams or lakes. If mains drainage is not available, a soak-away should be constructed in a place that cannot contaminate drinking water supplies. Water should not be allowed to simply soak into the ground, because this will create swampy conditions, which attract insects that contaminate products, as well as introducing a health hazard.

Toilets should be separated from the processing area by two doors or be located in a separate building. Workers should have hand-washing facilities with soap and clean towels. A summary of the basic rules on hygiene and sanitation are given in Table 2.1. Details of cleaning specific items of equipment are given in Section 5.

Remember:
The Uganda Bureau of Standards will inspect each aspect of your production facilities before they will award a product registration certificate.
Please review the Code of Practice for Hygiene in the Food and Drink Manufacturing Industry, US 28:2001.
It is obtainable from the Bureau of Standards.

Table 2.1. Basic rules of hygiene and sanitation

Basic rules for hygiene and sanitation in fruit and vegetable processing

Facilities required in the processing room

- A changing room where clothing and shoes that are not worn for work can be stored.
- Separate hand-washing facilities for staff, with soap, clean water, nail brushes and clean towels.
- Toilets, which should be separated from the processing room by two doors or located in a nearby building.
- First aid materials.
- Protective aprons or coats washed regularly, hats/hairnets and if necessary, gloves and shoes.
- Cleaning chemicals, stored away from the processing room.

Ways of working

- Clean the processing room, toilets, washing facilities and storerooms every day
- Use the correct chemicals to clean equipment, make sure there are no food residues and rinse the equipment with clean water.
- Make sure all cleaning cloths are washed and boiled each day. Do not hang them on equipment, or put them on products or window ledges to dry.
- Do not leave dirty equipment until the end of the day before cleaning it.
- Keep the area around the processing room clean and tidy. Keep grass cut short.
- Put all wastes into bins that are not used for anything else. Empty the bins periodically during the day away from the processing site. Clean up any spillages as they occur.
- Prevent all animals from entering the processing area or storerooms.
- Visitors should only enter the processing room wearing protective clothing and under supervision.
- Do not wear clothing or jewellery that can get caught in machinery.
- Wear a hat that completely covers the hair. Do not comb your hair in a processing room or storeroom.
- Cover all cuts, burns and sores with a clean, waterproof dressing. Do not handle any food if you have sores, boils, septic spots, a bad cold, sore throat or a stomach upset. Report any of these to the manager and do alternative work
- Do not smoke or eat in any room where there is open food because bacteria can be transferred from the mouth to the food.
- Do not spit in a processing room or storeroom.
- Wash hands and wrists thoroughly with soap after using the toilet, eating, smoking, coughing, blowing your nose, combing your hair, handling waste food, rubbish or cleaning chemicals. Dry them on a clean towel before handling food again.
- Keep fingernails cut short.
- Do not wear perfume or nail varnish as these can contaminate products.
- Do not cough or sneeze over food.
- Keep food covered wherever possible.
- Keep all food, tools and equipment off the floor.
- Keep ingredients in sealed containers.
- Do not use broken or dirty equipment.
- Report any signs of insects, rodents or birds to the manager.

Checklist 2

Can you answer the following questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.

Question	Tick	Notes
1. Is your site close to supplies of raw materials?		
2. How can you reduce the cost of transporting raw materials to your site?		
3. Does the processing room have a panelled ceiling?		
4. Do you need roof vents to reduce the temperature in the processing room?		
5. Are the walls easily cleaned? What do you need to do to improve them?		
6. Are doors and windows protected against insects? If not what improvements do you need to make?		
7. Is the floor free of cracks and easily cleaned?		
8. Do you have drainage that is protected against entry by rodents?		
9. Are lighting and power adequate? What do you need to do to improve them?		
10. Are the quantities, quality and safety of the water adequate for processing and cleaning?		
11. Do you have toilets and hand-washing facilities?		
12. Do your workers have a cleaning plan and do they follow good sanitation practices?		

3 Production Planning

Production planning involves thinking ahead to make sure that everything is in place to produce the required amount of product. Inadequate planning causes stoppages in production because for example, not enough fruit is bought, an ingredient is used up, or there are not enough staff to produce the required amount of product in the time available.

The short harvest season for many raw materials means that everything must be in place and working properly at the start of the harvest so that enough crop can be processed to produce sufficient product for the following year.

The amount of less perishable ingredients, such as sugar, salt or spices and packaging materials that are stored as stock depends on a number of factors:

- A large amount of stock ties up cash while it is waiting to be used.
- Some stock deteriorates over time and money is lost due to spoilage
- If processors buy smaller quantities more often, this is more expensive than buying in bulk.

Decisions on stock levels therefore depend on the cost and reliability of supplies, their shelf life and the amounts that are used each day.

If production stoppages happen too frequently, the amount of product available for sale falls to a level where the business cannot afford to pay the bills and it fails. Successful business people manage their cash flow, so that enough money is available to buy the inputs needed for production, before income is received from the sale of products. To do this they plan their production carefully.

Careful production planning is used to find the:

1. Number of workers required and their different jobs
2. Equipment needed to achieve the planned production level
3. Weights of raw materials and ingredients to be bought
4. Number of packages required
5. It can also identify any ‘bottle-necks’ in the process.

Carefully written plans can also help the entrepreneur to identify potential food safety risks and can be used to implement Good Hygienic Practice and Good Manufacturing Practice programmes.

Production can be planned using the calculations below. The information required to do this includes:

How much product (kg or litres) is <u>sold</u> (not made) each month?

- How many hours are worked per day?
- How many days are worked per month?

This information is first used to calculate the daily production rate, so that ingredients and packaging can be ordered. Then the average amount of production per hour (termed the

'product throughput') can be calculated to find the size of equipment and numbers of workers required.

Daily production rate

The daily production rate is calculated as follows:

$$\text{Production rate (kg or litres/day)} = \frac{\text{amount of product sold/month (kg or litres)}}{\text{N}^{o} \text{ days production/month}}$$

This figure is used to decide how much raw material, ingredients and packaging to buy.

Every effort should be made to ensure that the production rate is calculated as accurately as possible by carefully checking all the figures and the assumptions.

One of the main causes of error is to over-estimate the number of working days, particularly if there are regular power failures or if staff is often absent.

Raw materials and ingredients

Having decided how much product to make, a processor needs to calculate how much fruit or vegetables to buy. This is based first on the recipe for the product and secondly on the likely levels of wastage and losses during the process.

Worked example 1: calculating weights of ingredients from a recipe.

A recipe for mango chutney (from Table 4.7) is shown in the left column of the table below and the amounts of ingredients needed to make 50 kg are shown in the right column, with the calculation in the centre.

Recipe		Calculation	Amount needed to make 50kg
Mango	500g	(500/803.5) x 50	31.1 kg
Sugar	300g	(300/803.5) x 50	18.7 kg
Ginger	0.5g	(0.5/803.5) x 50	31.1 g
Mustard	0.5g	(0.5/803.5) x 50	31.1 g
Chillie	1.0g	(1.0/803.5) x 50	62.2 g
Garlic	0.5g	(0.5/803.5) x 50	31.1 g
Salt 1.0g		(1.0/803.5) x 50	62.2 g
Total	**803.5g**		**50.0 kg**

However, the amounts of raw material and ingredients that are calculated from the recipe are not the amounts that are used. Losses arise from peeling, from spoiled raw materials that are thrown away during sorting, from spillage during filling into packs, or from food that sticks to equipment and is lost during washing. Typical losses are shown in Tables 3.1 and 3.2, but it is important that processors should measure these in their own process so that accurate figures can be used in the calculations.

The amount of usable food after raw materials are prepared for processing is known as the 'yield' and is calculated as follows:

$$\text{Yield (\%)} = \frac{\text{weight of raw material actually used in the process}}{\text{weight of raw material that is bought}} \times 100$$

The true cost of raw materials depends on the yield and can be calculated as below:

$$\text{True raw material cost} = \frac{\text{Supplier cost}}{\text{\% yield}} \times 100$$

Worked example 2: calculating the true cost of raw materials

Pineapples cost USh 200 each and on average a single fruit weighs 1250g (i.e. Ush 160/kg). 30 kg are bought for USh 4800 and after peeling and coring there is 15.5 kg available for processing.

$$\text{Yield} = \frac{15.5}{30} \times 100 = 51.7\% \text{ (i.e. 48.3\% is waste)}$$

$$\text{The true cost of the usable part of a single fruit} = \frac{200}{51.7} \times 100 = \text{USh } 387$$

Table 3.1.Typical losses during the preparation of fruits and vegetables

Fruit or vegetable	Typical losses (%)	Notes
Apples	25	peeled & cored
Apricot halves	12	de-stoned
Bananas	40	peeled
Cabbages	30	-
Carrots	4	(bought without leaves)
Cauliflowers	38	-
Currants	3	seeds & skins removed
Figs	2	-
Grapes	19	skins & pips removed
Guavas	22	-
Lemons	40	peel & seeds removed
Mangoes	45	peeled & de-stoned
Melons	42	peel & seeds removed
Okra	12	-
Onions	3	-
Oranges	25	peel & seeds removed
Passion fruits	58	peel & seeds removed
Paw paws	38	peel & seeds removed
Peas	50	bought in pods
Peppers - chilli	15	seeds & stalk removed
Peppers - green	14	seeds & stalk removed
Pineapples	48	peeled & cored
Plantains	39	peeled
Tomatoes	4	seeds & skin removed

(Source: Fellows, P., Midway Technology Ltd, Bonsall, UK, 1997)

Table 3.2. Typical losses during processing of fruits and vegetables.

Stages in a Process	Typical Losses
Washing fruits/vegetables	0-10
Sorting	5-50
Peeling	5-60
Slicing/dicing	5-10
Batch preparation/weighing	2-5
Boiling	5-10
Drying	10-20
Packaging	5-10
Machine washing	5-20
Accidental spillage	5-10
Rejected packs (does not include evaporation losses)	2-5

(Source: Fellows, P., Midway Technology Ltd, Bonsall, UK)

If the process involves removing water (by drying or boiling), the amount of final product is calculated by knowing the solids content before and after processing as follows (see Section 6.1 for calculation of solids and moisture contents).

Worked example 3: calculating the weight and value of fruit after drying.

Taking 15.5 kg of fresh fruit, initially the fruit contains 75% water and 25% solids.
Therefore 15.5 kg of fruit contain 11.6 kg of water and 3.9 kg solids
After drying the weight of solids has not changed (only water is removed) and the moisture content is reduced to 8%.

Therefore the solids content is (100 - 8) = 92%

If 3.9 kg solids is 92%, then the total weight of product = $\frac{100}{92}$ x 3.9 = 4.2 kg

Therefore (15.5 - 4.2) = 11.3 kg water is removed

There were also losses of 200g due to rejected dried fruit. Therefore 4 kg of product is available for sale.
Ignoring other production costs (labour, depreciation etc.) the value of the product is therefore:

$$\frac{\text{Cost of raw materials}}{\text{Weight of product}} = \frac{\text{USh 4800}}{4} = \text{USh 1200/kg}$$

i.e. processing has increased the value of the fruit from Ush 160/kg to Ush 1200/kg

It is in the interests of the processor to reduce product losses as much as possible. Good quality raw materials and well-managed operation reduce wastage. This is especially important during later stages of a process when value has been added to the product.

A similar type of calculation is needed when boiling fruit and vegetables to find the weight of product left after boiling (although these losses are from evaporated water and they are necessary to obtain a good quality product).

Worked example 4: calculation of boiling losses:

The solids content in the mix of ingredients before boiling is found as follows:

Ingredient	Weight (kg)	Solids content (%)	Weight of solids (kg)
Mangoes	31.1	15	4.67
Sugar	18.7	100	18.7
Total	49.8		23.37
Total weight after 10% wastage	44.8 kg		21 kg

$$\% \text{ solids in batch before boiling} = \frac{21}{44.8} \times 100 = 46.9\%$$

So 21 kg equals 46.9% of the batch before boiling. After boiling there is no loss of solids (only water is removed) but the solids content has been increased to 70%.
Therefore 21kg equals 70%.

$$\text{Therefore the total weight of the batch after boiling} = \frac{100}{70} \times 21$$

$$= 30\text{kg}$$

And boiling losses are (44.8 – 30) = 14.8 kg

Packaging

When selecting packaging materials, the processor should consider:

- technical requirements of the product (for protection against light, crushing, air, moisture etc.)
- the design (for promotional and marketing requirements) and
- the relative cost and availability of different types of packaging.

Packaging is often the biggest problem for small-scale processors in Uganda and advice should be sought from food technologists at Makerere University or UIRI, or agents of packaging manufacturers.
New glass jars and bottles are only available as imports from Kenya or South Africa. Because of their heavy weight, high bulk and fragility, they are expensive to transport and breakages can be high if they are not properly packed. There are also minimum order sizes, which may be too high for individual small-scale processors. One possible role of UCOFPA could be to place bulk orders for containers for a number of its members.

Re-used containers are collected and sold in Uganda, but great care is needed to ensure that they are properly cleaned, because they may have been used to store chemicals, such as pesticides or kerosene. This is time-consuming, but bottle cleaners and rinsers can be constructed to save time and labour costs (Section 5.4).

The daily production rate is used to calculate the numbers of packages required.

Worked example 5: Calculation of number of packs required and time to fill and seal them

If 25 kg of dried fruit is produced per day and packed into 100g bags and there are 50 bags in each cardboard distribution box:

$$\text{the number of bags required} = \frac{25 \times 1000}{100} = 250 \text{ bags}$$

and the number of boxes = 250/50 = 5 boxes

If on average it takes a worker 45 seconds to fill and seal a bag,
the time required = 250 x (45/60) mins = 188 mins (3 hours, 8 mins)
or if 4 people are working together the time required is just over ¾ hour.

Both new and re-used containers should be sealed with new caps, lids or corks to achieve an adequate seal. The most common jar lids are now the TOTO (twist-on, twist-off) type. Bottles are sealed using ROPP (roll-on-pilfer-proof) caps, crown caps or corks made of natural material or plastic.

Plastic pots and bottles are becoming increasingly common in Uganda because of their lower production and distribution costs. Pots can be either sealed with a foil lid or with a snap-on plastic lid.

The most common type of plastic film is polythene although increasingly there are agents who can supply polypropylene. More sophisticated (and expensive) imported laminates are not yet available.

Small laminated plastic/foil/cardboard cartons of imported juices are appearing in Uganda, but these are not available to small-scale processors. They are only sold under licence to large-scale manufacturers (such as the Dairy Corporation) who also buy the UHT processing technology for which these packs are used. Other cardboard and paper packaging is more widely available and can usually be printed by local print companies.

Details of suppliers of packaging materials are given in the UNIDO Food Processing Equipment Directory.

Product throughput

The amount of material that passes through a process per hour is known as the throughput. This figure is important to calculate the correct size of equipment and the number of workers that are needed.

$$\text{Throughput (kg or litres/hour)} = \frac{\text{amount of product sold/month (kg or litres)}}{\text{N}^{o}\text{ day's production/month x N}^{o}\text{ hour's worked/day}}$$

Equipment

The throughput figure allows the processor to decide the size and/or number of pieces of equipment that are required. In doing this, decisions need to be taken on the benefits of employing a larger number of workers or buying a machine to do a particular job.

Worked example 6: calculating the size of equipment

Using a process diagram (from Table 4.8) the stages in jam making are identified as raw material preparation, boiling and packaging. Using a work plan (e.g. Figure 3.1) it is found that the time available to boil 36 kg of fruit/sugar mixture is 3 hours per day. The average throughput for the boiling stage is therefore:

$$36 \div 3 = 12 \text{ kg/hour}$$

A batch of jam should be boiled within approximately 20 mins to maintain the quality of the product and 2 batches per hour are therefore possible. Therefore the boiling pan should either have a capacity of 12 kg (e.g. a 15-20 litre pan) if the burner is large enough to process this amount of jam within 20 mins, or a smaller and cheaper pan (e.g. 8-10 litre capacity) could be used to boil two batches of 6 kg per hour.

It is preferable to buy equipment from local suppliers and fabricators because servicing and spare parts should be faster and easier to obtain. Information on the types and suppliers of equipment is given in the UNIDO Food Processing Equipment Directory.

If equipment has to be imported, the following points should be considered when ordering equipment:

- specify exactly what is required (many manufacturers have a range of similar products).
- give the throughput required in kg or litres per hour and the type of food to be processed
- where possible, give other information (model number of machine, single or three-phase power, number and types of spares required).

Another source of information is the UMA equipment database, or Internet access to locate databases of equipment manufacturers. Information on equipment importers is also available at offices of development agencies, the Chamber of Commerce, Makerere Department of Food Science and Technology, UIRI, or at embassies of exporting countries. (See contacts in Annex A).

Equipment maintenance

Another reason for lost production is delays caused by waiting for spare parts after equipment breaks down. Most small-scale producers do not keep a stock of spare parts because of the cost. However, few have compared the cost of spares with the losses caused by delayed production (especially if delivery times for spares are several weeks). Processors should monitor the state of equipment that is likely to wear outland with experience, they should buy spare parts or have the machine serviced when they expect that a component will wear out. Processors can also make an agreement with a mechanic to ensure that they come quickly to repair equipment. Details of maintenance of individual equipment are given in Section 5.

Staff

The numbers and types of workers needed to operate a fruit or vegetable processing business depend on the amount of production and also on the degree of mechanisation of the process. This type of processing is more seasonal than many other types and temporary staff is commonly employed during harvest times. Machinery such as a pulper finisher for juice preparation, or machines for filling and sealing packages, can significantly reduce the numbers of workers needed. However, a processor needs to carefully compare the cost of labour with the cost of maintenance, spare parts and possibly loan repayments from buying the equipment to see which is most cost-effective.

When deciding the number of people needed to produce a particular amount of product, the process charts in Section 4 can be used to break down a process into different stages. A decision can then be taken on whether a particular stage can be done manually and the number of people who will be needed, or whether a machine will do the work. It is important also to include work such as store management, quality assurance and bookkeeping when planning the number of staff members that are needed.

It is possible to have all workers doing the same type of work throughout the day (e.g. everyone prepares fruit together then moves on to load a dryer together and then all pack the previous day's production). However, it is often more efficient to allocate different jobs to each worker as the day progresses. A convenient way of planning this is to draw an Activity Chart (Figure 3.1). This shows the type of work that is to be done each hour during the day, the number of people involved and the sequence of work that individuals do during the day. This type of chart can also be used to train workers in each of the different jobs in a process.

Health and safety

All processors have a responsibility to provide safe and healthy working conditions for their staff. In fruit and vegetable processing the main dangers are as follows:

Damage to skin

When workers handle raw fruit over several hours, they should wash their hands regularly or be provided with thin gloves to prevent skin damage from fruit acids. In particular, care is needed with pineapples, which contain an enzyme that attacks the skin. Care is also needed when handling bleach to avoid damage to the skin.

Burns and cuts

The main risk of burns comes from large containers of viscous products such as jam or sauces, which are handled at boiling temperatures. Aprons or coats and heat resistant gloves should be provided and staff should be trained to handle such foods safely (Table 3.2). There are also dangers of cuts from sharp blades on motorised cutters or liquidisers. Staff should be properly trained to use machines safely, particularly when cleaning them and workers should not wear cloths or jewellery that could become tangled in moving equipment.

Figure 3.1 Activity chart used to plan job allocations for fruit processing staff

Time	Supervisor	1st operator	2nd operator	3rd operator
8 am	Management/book keeping	Washing/sorting crops	Washing/sorting crops	Store management
9 am	Management/book keeping	Peeling/slicing fruit	Peeling/slicing fruit	Peeling/slicing fruit
10 am	Management/book keeping	Filling/sealing containers	Peeling/slicing fruit	Mixing/boiling products
11 am	Management/book keeping	Filling/sealing containers	Labelling	Mixing/boiling products
12 am	LUNCH			
1 pm	Management/book keeping	Filling/sealing containers	Labelling	Filling/sealing containers
2pm	Distribution	Cleaning	Labelling	Store management
3 pm	Distribution	Cleaning	Cleaning	Cleaning
4 pm	Distribution	Cleaning	Preparation for next day's production	
5 pm	Distribution			

Table 3.2. Summary of safe working practices in fruit and vegetable processing

• Do not leave metal stirrers in boiling liquids.
• Do not leave handles of boiling pans over the heat source.
• Carry knives with the point down. Do not try to catch falling knives.
• Cut fruits and vegetables on a board and not using the other hand.
• Do not use a damp cloth to carry hot pans.
• Wear shoes that protect your feet from falling or hot objects.
• Cover burning cooking oil with a damp cloth. Never use water to put out flames.
• Shield gas burners from direct sunlight because the flames can become invisible.
• Do not carry large containers of hot food on your own; get assistance.
• Do not put cleaning fluids into old food containers.

The machinery used in Uganda does not have fail-safe devices such as electrical cut-out switches and it is essential that motorised equipment is switched off before cleaning and maintenance.

Record Keeping

There are four sets of records that should be kept by the owner of a small fruit and vegetable processing unit:

1. Financial records
2. Production records
3. Quality assurance records
4. Sales records.

As with other inputs to a business, keeping records is an investment of time and money and this must be related to the scale and profitability of the business (the benefits must outweigh the costs).

Records must be used for them to have any value.

This means that the processor must understand why the information is collected and what it can be used for. Processors should also put in place a system of checks to ensure that one person does not have responsibility for a whole area of record keeping. For example the person who keeps records of purchases should be different to the person who records levels of stocks and manages the storeroom.

Table 3.3. Types of records for a small-scale fruit and vegetable processing business

Type of record	Information to be recorded
Production records	Recipes Raw materials and ingredients received and suppliers Wastage % at different stages of the process Stock levels for each ingredient Production volumes and measurements Maintenance programs and schedules
Quality assurance records	Target amounts of ingredients and any changes made to recipe Measurements made at process control points Batch numbers and product code numbers Cleaning procedures and schedules
Sales records	Names of customers and amounts sold to each Weekly and monthly sales volumes
Financial records	Income from sales Costs of all process inputs Staff records Cash flow Profit/loss Tax records Bank statements

(Source: Fellows, P., Midway Technology Ltd, Bonsall, UK)

Checklist 3

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer.

Question	Tick	Notes
1. Do you know how to calculate your production rate?		
2. Do you know how to calculate the amounts and true costs of ingredients required for a given production rate?		
3. Do you know how to calculate the yield of product and levels of wastage?		
4. Do you know how to calculate moisture losses during drying and boiling?		
5. Do you know how to plan labour requirements and how to allocate jobs to different workers to maximise efficiency?		
6. Can you calculate equipment size requirements using product throughput?		
7. Do you have correct maintenance procedures for your equipment?		
8. Have you developed safety training and checked the process to ensure that equipment and procedures are safe?		
9. Do you keep adequate records?		

4 Products and Production Methods

Potentially each of large number of fruits and vegetables that are grown in Uganda could be used to make the range of products shown in Figure 4.1. There are too many to describe them all in detail and categories of products have therefore been grouped together in this section according to the current (2003), levels of demand in Uganda. Products that have a high demand include:

- dried fruit (pineapple and banana for export)
- fruit wines (especially pineapple)
- fried snacks (banana or potato chips)
- juices (pineapple and passion fruit)
- squashes and cordials
- tomato sauce.

Products that have a smaller demand at present include:

- jams, jellies and marmalades
- bottled fruits
- chutneys and pickles
- purees and pastes

The high demand for products in the first category has led to strong competition as more and more small-scale processors start to produce these products. Processors should therefore try to diversify into new varieties and experiment with new types of processed fruit and vegetables. At present there appears to be no commercial production of dried vegetables, pectin, fried snacks (other than banana) (See Root Crop Processing Manual for potato, cassava and sweet potato snacks), crystallised fruits, vinegar, nectars or fruit 'cheese'. One processor is currently exporting papain. The lack of competition opens opportunities for processors to make some of these products and they are therefore included in the third category in this manual.

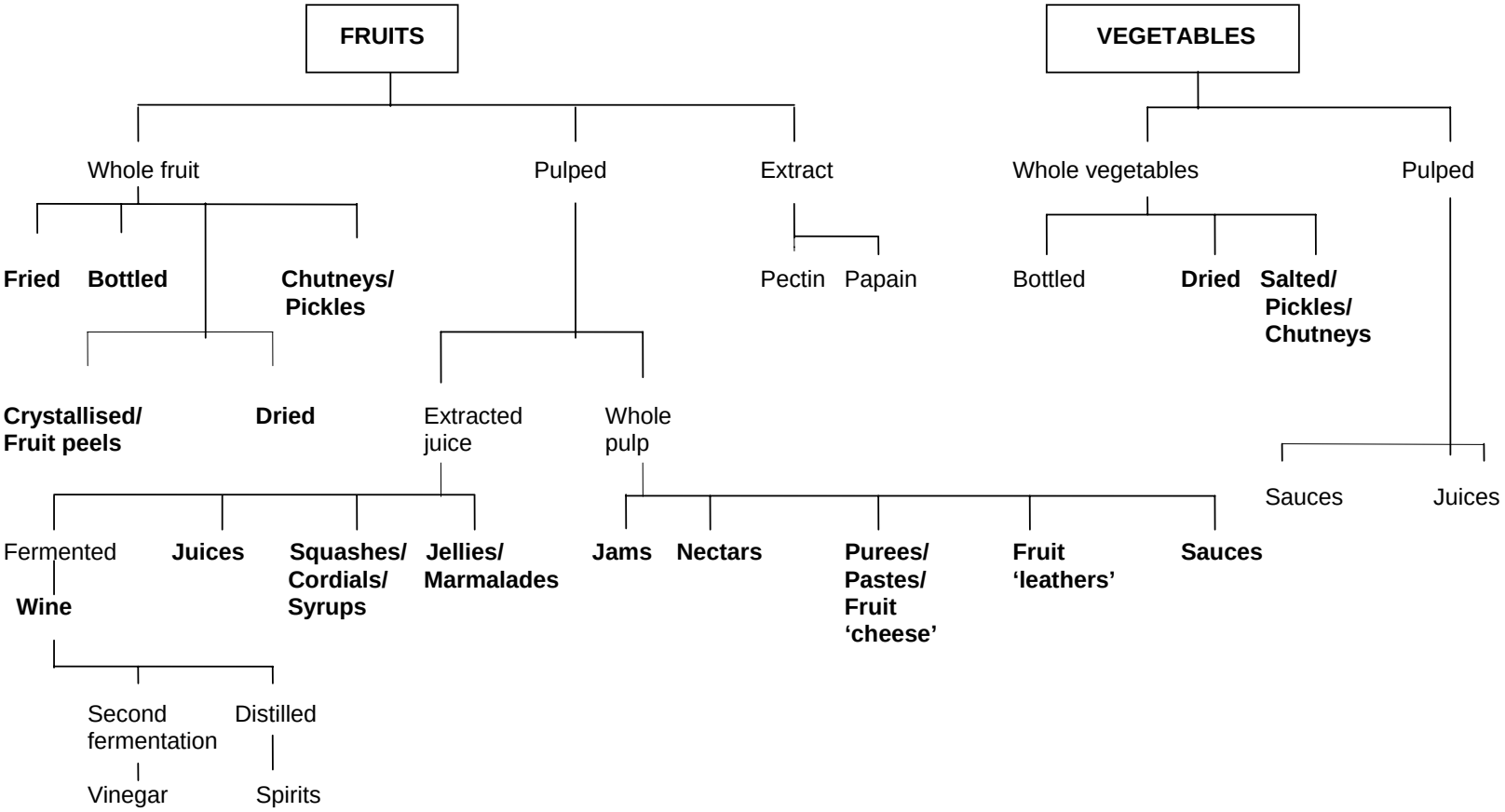
The products in bold in Figure 4.1 are described in the tables below, with the process stage on the left and notes on processing conditions, equipment and quality assurance checks on the right for each stage in the process.

The processes are arranged in groups according to current levels of demand for the products as above:

1. products that have a high demand
2. products that are produced but currently have a lower demand
3. products that are not currently produced but may have a demand in future (bottled fruits, crystallised fruits, fruit leathers and cheeses and syrups).

The manual does not include details of canned products, vinegar or spirits for the reasons given in Annex B.

Figure 4.1 Fruit and vegetable products



(Adapted from: Fellows, 1997)

Products that have a high demand

Fried products

Starchy fruits such as banana can be fried and eaten as snack foods (Table 4.1). Heat destroys enzymes and micro-organisms and moisture is removed which prevents re-contamination. When products are packed in moisture-proof, light-proof and airtight containers, they can have a shelf life of several weeks or months. The main cause of spoilage is rancidity of frying oil that remains on the product.

The temperature during frying should be carefully controlled, preferably using an electric fryer with a thermostat control. The temperature of the oil should not be allowed to get higher than the ‘smoke point’ of the oil (when a blue haze forms above the oil). If this happens, it is a sign that the oil is breaking down, getting thicker and developing an unpleasant flavour that makes the product unacceptable. When the oil gets thicker, more of it sticks to the product, which increases production costs and reduces the product shelf life.

Table 4.1. Process for fried fruits

Stage In Process	Notes
Inspect ↓	Select fruit that is slightly under-ripe and has a firm texture. Remove mouldy, rotten, and badly damaged fruit. **Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.**
Pre-wash ↓	Pre-wash to remove surface contaminants, e.g., pesticide residue, insects, soil or dirt, etc.
Peel ↓	Peel by hand.
Slice ↓	Using a knife. A thinner, more uniform product can be made using small manual or electric slicing machines. Check that the thickness of slices is 1-2 mm.
Wash ↓	Wash with potable water in a bowl or wash tank to separate the slices. Citric acid or sodium meta-bisulphite can be added to the wash water at 10 g/litre to keep the colour and prevent darkening of the fruit.
Drain ↓	To prevent excess water being added to the hot oil
Fry ↓	At 180-200^{o}C for 5-10 minutes using a pan over a fire or in a deep fat fryer, until the required golden colour has formed. Regularly check oil quality (see text). Care is needed when adding fruit to hot oil to prevent splashing.
Drain/cool ↓	On racks or mesh. Collect drained oil and reuse it. Cool product to room temperature to prevent condensation forming inside the package.
Pack/label ↓	In plastic bags using a heat sealer. Check the fill weight. Check that the seal is correctly formed because the product shelf life is reduced if air or moisture enters through a poorly formed seal. Polypropylene gives a longer shelf life than polythene. If a paper label is used, this should either be on the outside of the pack or a double layer of film is used to avoid oil seepage into the paper.
Store	Store away from heat and sunlight to avoid the development of a rancid taste in the product.

Dried fruits and vegetables

Dried fruits, vegetables, herbs and spices are low-volume, high-value foods that can be profitable for small-scale processors if there is sufficient demand. Recent increases in demand for organic dried fruit in Europe have stimulated a number of new businesses in Uganda. Drying preserves fruits and vegetables because it removes most of the water needed by enzymes and micro-organisms to spoil them. However, drying can also cause unacceptable changes to the colour, flavour and texture if the drying conditions are not properly controlled.

Blanching

Some vegetables are blanched before drying to prevent colour changes and to reduce the number of contaminating micro-organisms, because the temperature of drying is not high enough to kill them. In hot water blanching, vegetables are immersed in boiling water in a wire basket. The bright green colour of some vegetables can be protected using 1% sodium bicarbonate in the blancher water and the texture of soft vegetables can be protected using a 2% calcium chloride solution. Both can be bought from pharmacies in larger towns. For steam blanching, vegetables are placed in a strainer over a pan of boiling water and covered with a lid to prevent the steam escaping. Steaming takes longer than water blanching, but fewer nutrients are lost.

Table 4.2. Blanching times for vegetables

Food	Blanching time (minutes) using	
	Steam	Water
Leafy vegetables	2 - 2.5	1.5
Sliced beans	2 - 2.5	1.5 - 2
Squashes	2.5	1.5 - 2
Cabbage	2.5	2
Peas	3	3.5
Carrots	3 - 3.5	3 - 4
Cauliflower	4 - 5	5 - 6
Potatoes	6 - 8	8 - 12

(Source: Fellows, P., Midway Technology Ltd, Bonsall, UK, 1997)

Sulphuring and sulphiting

Sulphur dioxide protects the natural colour of some fruits (banana, pineapple etc), although it should not be used with red fruits because it bleaches the colour. It can be produced either by burning sulphur (sulphuring) or using a solution of sodium sulphite, sodium metabisulphite or potassium metabisulphite. In sulphuring, cut or shredded fruit is placed on mesh trays inside a wooden cabinet. 350-400g sulphur are burned per 100kg fruit for 1-3 hours, depending on the type of fruit, its moisture content and legal limits on residual sulphur dioxide in the product (Section 6.2). In sulphiting, the chemical is either added to the blancher water or made into a sulphite dip. Fruits are dipped for 5-10 minutes. About two thirds of the weight of sodium metabisulphite is present as sulphur dioxide when it is dissolved in water. A 0.001% (1000 ppm or 1 g/litre) solution is therefore made by dissolving 1.5g sodium metabisulphite/litre. Sulphiting can also be used to temporarily preserve fruits and spread production throughout the year. The residual sulphur dioxide level is important if dried fruit is made for export, because many importers specify either very low levels or do not allow its presence. It should not be used for organic dried fruits. Processors should

consult their buyers to find out what, if any level is acceptable. The National Food Safety Law may also address the issue of sulphuring.

Other treatments

Some vegetables and fruits (such as limes for lime pickle) are salted before drying. The high salt concentration preserves the food by both drawing out water and by the anti-microbial properties of the salt. Vegetables must be washed to lower the salt concentration before they are eaten.

Packaging

Dried fruits and vegetables absorb moisture from the air and should therefore be packed in airtight, moisture-proof containers. Some also need protection from light to maintain their colour. Although pottery and metal containers can be used, they are more expensive and more difficult to handle than plastic films (although some bulk exports are packed into 200 litre metal drums). Polythene is the most widely available and cheapest film in Uganda, but it is not a good barrier to air and moisture. If affordable, polypropylene film gives better protection and a longer shelf life. Other more expensive films offer much better protection, but are difficult to find in Uganda. Dried fruits and vegetables need a cardboard carton for storage and distribution, to prevent crushing and to exclude light. Details of suppliers are given in the UNIDO Food Processing Equipment Directory.

Dried organic pineapple

Table 4.3. Process for dried fruits and vegetables

Stage In Process		Notes
Essential	**Optional**	
Fruit ▼		Harvest as carefully as possible to reduce bruising and other damage.
Inspect ▼		Remove mouldy, rotten, and badly damaged fruit. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks and stones. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
Wash ▼		Use wash tanks or special washers with clean, potable water to remove surface contaminants, e.g., pesticide residues, insects, soil or dirt, etc.
Sort/grade ▼		By hand select fruits with the same colour, size or maturity (fully mature but not over-ripe). Uniform size and maturity are important to get uniform drying times for all pieces. Over-ripe fruits are easily damaged and difficult to dry. Under-ripe fruits have poorer flavour, colour and appearance.
Peel ▼		Peel prevents moisture leaving the food and allows faster blanching, sulphur dioxide treatment and drying. Peel by hand using knives or peelers, or using small peeling machines. Check that all traces of peel are removed.
◄	Cut/slice/core	Depending on the type of fruit/vegetable, cut by hand using sharp stainless steel knives, corers etc. or using choppers, cutters, slicing or dicing machines. Check for uniform sized pieces.
◄	Blanch	For vegetables, using a boiling pan, heater, wire basket or steamer. Check water temperature, time of heating and concentration of any salts added (see text). Care is needed to prevent re-contamination of blanched foods before drying.
◄	Acid dip	Can be used to prevent browning of light coloured fruits and vegetables. It involves dipping fruit in 2% citric acid, lemon or lime juice for 5-10 minutes. Equipment required includes weighing scales or scoops and food-grade plastic tank.
◄ ▼	Treatment with sulphur dioxide	Optional for some fruits and vegetables, using either a sulphuring cabinet or a food-grade plastic tank for a sulphite dip (see text). Other equipment includes weighing scales or scoops. Check weight of sulphur or concentration of sulphite and time of exposure. **Safety: do not breathe fumes. Sulphur dioxide causes coughing and eye irritation.**
Dry ▼		The time needed for drying depends on the temperature, humidity and speed of the air, the type of dryer and the size of the food pieces. Check for mould growth, insect contamination and the temperature and time of drying.
Pack[1] ▼		Using an electric heat sealer to produce moisture-proof, airtight plastic bags. Check fill-weight and seal.
Label		Check that label is correct for type of product.
Store		Store in a cool dry place away from sunlight. Protect fragile foods from crushing.

[1] Flour can be made by grinding the dried fruit in a hammer mill before packaging.

Juices, squashes and cordials

Juices

There is a growing trend in urban centres of Uganda for higher juice consumption and this market may become much larger in future. Pineapple and passion fruit are the most popular juices to date, but others may increase in popularity. Banana juice is made using traditional methods for beer/spirit production, but is not widely sold as a juice. New technologies developed at Makerere University Department of Food Science and Technology could be applied to create small banana juice businesses. Juice can also be made from a mixture of fruits, although this is not widely done at present. Juice manufacturers face competition from producers who buy imported flavour concentrates and dilute them to make 'fruit drinks' that are much cheaper. The marketing of fruit juices should therefore focus on the fact that they are made from fresh fruits with no additives. There is also competition with Kenyan and South African juices that are sold in paperboard cartons. However, the cost of equipment to form and seal the cartons is too high for small-scale producers and they are only sold under licence. Cheaper alternatives including plastic pots with sealed foil lids are available as alternatives to bottles. Some processors have also found a market selling juice in polythene sachets.

Preservation is due to pasteurisation and the natural acidity of the juice. Some types of juice (e.g. melon juice) have low levels of acid and this can be increased by adding citric acid to give a pH below 3.5-4.0. Although some producers add a preservative such as sodium benzoate to ensure a long shelf life, this is not necessary if juice is properly processed. Unopened bottles should have a shelf life of 3-9 months, depending on the storage conditions and quality of the package. Juice production can be spread over a larger part of the year by processing a sequence of fruits or by part-processing pulps and storing them in 1000-2000 ppm. sodium metabisulphite solution. The sulphur dioxide is driven off during pasteurisation.

Juice can be extracted from fruits in a number of ways, depending on the hardness of the raw material. Soft fruits such as berries or tomatoes can be pressed in a fruit press, or pulped using a juicer attachment to a food processor. Equipment photos and descriptions can be found in section 5. Steamers, such as those used for blanching, can also be used to 'dissolve' some types of cut soft fruits such as melon and pawpaw. Tomatoes can be heated in a wire basket in boiling water for 10 minutes to loosen the skin before pulping. Citrus fruits are usually reamed to extract the juice without the bitter pith or skin. Harder fruits, such as pineapple, are peeled and pulped using a liquidiser and pressed to extract the juice. Passion fruit, tomato and other fruit juices can be prepared using a pulper-finisher that separates skins and seeds from the pulp. Passion fruit and pawpaw pulp should not be liquidised unless the seeds are removed first, because the fast-moving blades chop the seeds into small pieces that then appear to be contaminants. When a clearer juice is required it is necessary to filter it through a fine cloth or stainless steel juice strainer. Although this will not produce a crystal clear juice, this is not required for the market in Uganda. A crystal clear juice requires a filter press, which is a considerable investment for a small-scale processor.

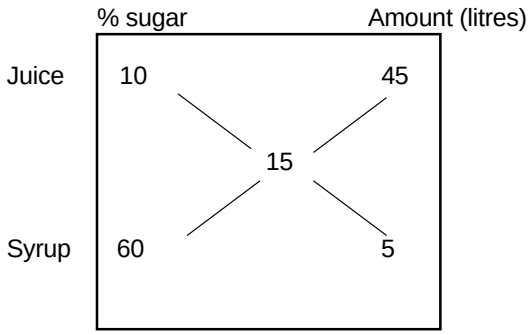
Squashes and cordials

Squashes are made from fruit juice mixed with sugar syrup. Cordials are crystal-clear squashes. The process involves producing juice, which is then filtered through fine cloth, or special juice filters to make it crystal-clear for cordials. A 50-60% solution of filtered sugar syrup is heated to 90^{o}Cand mixed in the correct proportion with the juice. Adding hot sugar syrup to juice reduces the time that the juice is heated and the colour and flavour are better

preserved. This method can also be used to reduce equipment costs because sugar syrup can be heated in a large aluminium pan, which is cheaper than stainless steel. A small stainless steel pan is then used to finish heating the juice/syrup mixture.

A simple way of calculating the amounts of sugar and juice that should be mixed together (also when making jams) is to use a Pearson Square (Figure 4.2). To use it, draw a square, writing the juice and syrup concentrations on the left side and the required product concentration, e.g. 15%, in the middle. Subtract the smaller amount from the larger amount diagonally to find the quantities that should be mixed together (in the example, 45 litres of juice should be mixed with 5 litres of sugar syrup).

Figure 4.2. A Pearson Square used to calculate the amounts of two ingredients in a mixture



(From: Food Chain, N° 17, p15, March 1996)

These drinks are diluted to taste with water and are therefore used a little at a time, so they may contain a preservative (usually sodium benzoate) to prevent spoilage after opening. Although some processors use food dyes, these are not necessary for most products. Regulations on the composition of squashes are given in Section 6.2.

Passion Fruit Juice

Table 4.4. Process for fruit juice

Stage In Process		Notes
Fruit ↓		Mature but not over-ripe fruit without mould growth, picked carefully to reduce puncturing, splitting or bruising etc. Transport in stackable boxes to avoid crushing.
Inspect ↓		Remove mouldy, rotten, and badly damaged fruit. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks and stones. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
Wash ↓		Wash in clean, potable water in a wash tank to remove surface contaminants, e.g. pesticide residues, insects, soil or dirt, etc.
Sort/grade ↓		Sort by hand on a sorting table to get similar colour or maturity. **Shape and size are not important.**
Pulp ↓	← Peel/ core/ chop	Depending on the fruit, peeling and cutting are optional before pulping. Peels are removed by hand using sharp stainless steel knives or small peeling machines. Manual or motorised corers are available for pineapples. Fruits are pulped and skins and seeds are separated (see text).
EITHER ↓	← Heat	To 80-90^{o}C in a stainless steel boiling pan for 10-15 minutes. Check to ensure that colour does not darken excessively.
Fill/seal ↓		Pack into pre-sterilised bottles (boiled in water or in an oven for 10 - 15 mins) or in plastic pots or sachets if they can be adequately sealed against insects. Seal and check fill- weight and properly sealed lids/sachets. Re-used bottles should be carefully washed using detergent and thoroughly rinsed. An optional bottle rinser can be used to save time.
OR ←	Heat	Fill juice into bottles and pasteurise in hot water at 88-90^{o}C for 10-20 minutes depending on the size of the bottle.
Cool ↓		To room temperature, either by lying bottles on their side on a table or using a bottle cooler (optional).
Label ↓		By hand or with label applicator. Check that the correct label is used and that label quality is satisfactory. Check that each one is correctly aligned.
Store		Store in cool dry place away from sunlight.

Sauces

In principle, sauces can be made from almost any combination of pulped fruit or vegetable, boiled with salt, sugar, spices and vinegar. However, in practice the market in Uganda is dominated by tomato sauce and chilli sauce. (The Ugandan standard for tomato sauce can be found in US 39:1999) The heat during boiling destroys micro-organisms and the high level of acids, salt and sugar prevents mould growth. The amounts to add are found using a 'Preservation Index'. An index above 3.6 preserves the sauce and allows it to be used a little at a time after the bottle has been opened. Some producers add a preservative such as sodium benzoate, but this is not necessary if the correct Preservation Index is achieved. This can be calculated as follows (sugar is measured as 'total solids'):

$$\frac{\text{Total acidity} \times 100}{(100 - \text{total solids})} = \text{not less than } 3.6$$

Details of how to measure acidity and total solids are given in Section 6.1. If a manufacturer has no access to basic laboratory equipment, a sample of product can be tested by the Uganda Bureau of Standards or Makerere University Department of Food Science and Technology, which can also recommend adjustments to the recipe if necessary. At a small scale, sauces are made in pans, heating slowly with constant stirring to avoid burning the product.

Table 4.5. Process for sauces

Stage In Process		Notes
Vegetable or fruit ▼		Mature but not over-ripe fruit or vegetables picked carefully to reduce puncturing, bruising etc. Transport in stackable boxes to avoid crushing.
Inspect ▼		Remove mouldy, rotten, and badly damaged raw materials. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks and stones. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
Wash ▼		Wash with clean, potable water in a wash tank to remove surface contaminants, e.g., pesticide residues, insects, soil or dirt, etc.
Sort/grade ▼		Sort by hand on a sorting table to get similar colour or maturity. Shape and size are not important.
Pulp ◄— ▼	Peel/ chop	Depending on the fruit/vegetable, peeling and cutting are optional before pulping. Peels are removed by hand using sharp stainless steel knives or small peeling machines. Tomatoes can be placed into a wire basket and heated in boiling water for 10 minutes to loosen the skin. They are then removed and peeled by hand. Fruit/vegetables can be pulped in a liquidiser or a pulper-finisher can be used for soft fruits and separate pulp from skins and seeds.
Mix ▼		Different mixtures of salt, sugar, vinegar and spices are used depending upon the product and local tastes. A typical recipe for tomato sauce is (per kg of tomatoes) 10g salt, 200ml vinegar (containing 10% acetic acid) and 80g sugar, 1g each of cinnamon, ground cloves, allspice and cayenne pepper, in a tied muslin bag submerged in the pulp. Check weights of ingredients. Use a food grade plastic mixing tank and scales, (pH meter optional)
Heat ▼		To 80-90^{o}C in a stainless steel boiling pan until thick, usually within 20 minutes. Vinegar is added towards the end of boiling to reduce losses of acetic acid by evaporation (refractometer optional). Check to ensure that colour does not darken excessively. Remove spice bag.
Fill & Seal ▼		Pack into pre-sterilised bottles (boiled in water or in an oven at 100^{o}C for 10-15 mins) or in plastic pots or sachets if they can be adequately sealed against insects. Seal and check fill- weight and seals. Re-used bottles should be carefully washed using detergent and thoroughly rinsed. An optional bottle rinser can be used to save time.
Cool ▼		To room temperature, either by lying bottles on their side on a table or using a bottle cooler (optional).
Label ▼		By hand or with label applicator. Check that the correct label is used and that label quality is satisfactory. Check that each one is correctly aligned.
Store		Store in cool dry place away from sunlight

Wines

Wines are produced by fermentation of fruit juice or pulp by varieties of the yeast *Saccharomyces cerevisiae*, named 'wine yeasts'. Sugars in the juice together with added sugar, are converted into alcohol and carbon dioxide. During fermentation, it is important to keep air out of the vessel to enable the yeast to produce alcohol and to prevent contamination by bacteria and moulds. Wines are preserved by their natural acidity and raised levels of alcohol (8-13%). Almost any fruit can be used to make wine, but the most popular in Uganda is pineapple, followed by passion fruit, papaya, banana and strawberry (or strawberry flavoured) wines. The demand for wine is increasing, especially in Kampala and other large towns, but it is still regarded as a luxury product and the market is much smaller than for other alcoholic drinks. There are also relatively large numbers of wine producers and imported wines from South Africa and Kenya, so competition is therefore high.

Pineapple wine

Table 4.6. Process for fruit wine

Stage In Process		Notes
Fruit ↓		Mature but not over-ripe fruit without mould growth, picked carefully to reduce puncturing, splitting or bruising etc. Transport in stackable boxes to avoid damage.
Inspect ↓		Remove mouldy, rotten, and badly damaged fruit. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks and stones. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
Wash ↓		Use clean, potable water in a wash tank to remove surface contaminants, e.g., pesticide residues, insects, soil or dirt, etc.
Sort/grade ↓		Sort by hand on a sorting table for similar maturity. Shape and size are not important. Remove unwanted parts.
Pulp ↓ ←	Peel / core/ chop	Peeling and cutting are optional before pulping. Peels removed using sharp knives or small peeling machines. Manual or motorised corers are available for pineapples. Fruits pulped in a liquidiser or pulper-finisher. Check that all traces of peel are removed
Filter ↓		Coarse filter the pulp to produce a juice. A manual press increases juice yields.
Mix ↓		Add yeast (2-3% of weight of juice) and optional sugar (up to 20% depending on the sweetness of the fruit and the final product). Add yeast nutrient (optional) at approximately 1g per litre.
Ferment ↓		At 20-28^{o}C for 5-21 days in a clean fermentation vessel[1] fitted with an air lock to prevent air from entering. Transfer to fermentation drums fitted with airlocks after the initial fermentation. Fermentation is complete when gas bubbles are no longer produced and the yeast has settled out.
Clear & standardise ↓		Decant into a clean container. In some wines sediment settles over a few weeks, whereas others require clearing agents (e.g. gelatine, bentonite, perlite, tannin, isinglass). Adjust the alcohol content to 10-13%[2], as declared on the label, by blending with previous batches or adding clean water and check using an alcohol hydrometer.
Fill & Seal ↓		When crystal clear, cold fill into pre-sterilised bottles and fit sterilised corks (boiled for 10 minutes or soaked in sodium metabisulphite solution), plastic stoppers, or caps, depending on the type of bottle. Check fill-volume. Re-used bottles should be carefully washed using detergent and thoroughly rinsed.
Label ↓		Check that the correct label is used and that label quality is satisfactory. Check that each one is correctly aligned.
Store		Store on racks, bottles inclined with the cork down to keep the corks wet, or in cartons in a cool dry atmosphere away from sunlight.

[1] The main problems in wine making are caused by inadequately cleaned fermentation vessels, which contain micro-organisms that contaminate and spoil the wine. Adequate sedimentation or filtration is needed using clearing agents to produce a crystal-clear product.

[2] 15-25% for 'fortified' wines

Products that have lower demand

Chutneys

Chutneys are made by boiling vegetables or sour fruits with sugar, spices and sometimes vinegar if there is little acid in the fruit. If a dark product is required, sugar is added before heating, or it is added towards the end of boiling for a lighter product. The high sugar content and acid preserves the chutney after a jar has been opened. Some spices also have a preservative effect, in addition to contributing to the flavour of the chutney.

Mango Chutney

Table 4.7. Process for chutney

Stage In Process	Notes
Fruits/vegetables ▼	Fruits should be picked carefully to reduce bruising etc. and checked that they are fully maturity but not over-ripe. Vegetables should be fully mature.
Inspect ▼	Remove mouldy, rotten, and badly damaged fruits and vegetables. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks and stones. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
Wash ▼	Use clean, potable water in a wash tank to remove surface contaminants, e.g., pesticide residues, insects, dirt and soil, etc.
Sort/grade ▼	Sort by hand on a sorting table to get similar colour or maturity
Peel ▼	Most fruits and vegetables require peeling, but some chutneys include un-peeled fruits. Peel by hand using sharp stainless steel knives or small peeling machines that are made for some types of fruits. Check that all traces of peel are removed
Cut/slice/core ▼	Most fruits and vegetables are cut into thin strips or small cubes by hand using stainless steel knives, or using manual slicing or dicing machines. Pieces should be similar in size to produce uniform mixtures and allow faster penetration of sugar syrup into the pieces. Check for uniform sized pieces.
Mix ingredients ▼	Weigh ingredients and mix together in a stainless steel or food grade plastic mixing bowl.
Heat ▼	Boil the mixture in a stainless steel boiling pan with constant stirring, until it is thick and concentrated. Check the time and temperature of boiling. An optional check can be made of sugar content (68-70%) using a refractometer.
Fill & Seal ▼	Hot fill using a funnel or paste filler into pre-sterilised jars (boiled in water or in an oven at 100^{o}C for 10-15 mins). Manually seal lids and check fill-weight and properly sealed lid. Re-used jars should be carefully washed using detergent and thoroughly rinsed. An optional bottle rinser can be used to save time If jars are not obtainable, plastic pots or bags can be used, provided that they can be adequately sealed against insects.
Cool ▼	To room temperature, either by lying jars on their side on a table or using a bottle cooler (optional).
Label ▼	By hand or with label applicator. Check that the correct label is used and that label quality is satisfactory. Check that each one is correctly aligned.
Store	Store in cool dry place away from sunlight

Jams, jellies and marmalades

Jam is made using pulp from a single fruit or from a mixture of fruits. The combination of high acidity (pH around 3.0)and high sugar content (68-72%), prevents mould growth after opening the jar. Jellies are crystal-clear jams that are made using filtered juice instead of fruit pulp and marmalades are produced from clear citrus juices (lime, orange, grapefruit, lemon or orange) that have fine shreds of peel suspended in the gel. Ginger may also be used alone or mixed with the citrus fruits. The proportion of each fruit in a mixed fruit product is controlled by the Uganda Standard Specification for Jam (Fruit Preserves) and Jellies: US 31:1999. Citrus marmalades are controlled by US 32:1999.

There are two important points to remember when making jams, jellies or marmalades:

1) There must be the correct proportions of juice, sugar, acid and pectin in order to form a good gel. Checks that can be made to ensure that the proportions are correct are given in Section 6.1. In general, slightly under-ripe fruits contain more acid and pectin than do over-ripe fruits, but there are differences in the amounts of acid and pectin in different types of fruit (Table 4.8).

2) Water must be boiled off quickly to concentrate the mixture before it darkens. If whole fruit is used, there are two heating stages: at the start, the fruit is heated slowly to soften it and to extract pectin; then the mixture is boiled rapidly until the sugar content reaches 68-72%. This change in heat output requires a large and easily controllable burner. At a small scale, a stainless steel pan and a gas burner can be used[2], but the mixture should be constantly stirred to prevent it burning onto the base of the pan, particularly towards the end of boiling when it thickens. At higher production rates, a double-jacketed pan is better because it gives more even and faster heating and does not risk burning the product. Methods to test for the correct point to stop boiling are described in Section 6.1and a summary of common faults in jam making is shown in Table 4.10.

Table 4.8 Pectin and acid contents of fruits

Fruits that have sufficient acid and pectin	**Fruits that do not have enough acid <u>or</u> pectin**	**Fruits that do not have enough acid <u>and</u> pectin**
Unripe fruits: especially apple, quince, lemon, grapefruit, passion fruit, guava	Ripe fruits: especially apple, orange, mango,	Ripe fruits: especially melon, banana, strawberry, pineapple
Sugar:fruit juice ratio = 1:1	Sugar:fruit juice ratio = 0.6 to 0.75:1	Sugar:fruit juice ratio = 0.5:1

(Source: Fellows, P., Midway Technology Ltd, Bonsall, UK)

Pectin is available commercially as either a powder or a liquid concentrate. It is stable if stored in cool, dry place and it will only lose about 2% of its gelling power per year. Powdered pectin is added to fruit pulp at 3-6g per kg of final product, but it should first be mixed with about five times its weight of sugar to prevent lumps forming when it is added to the pulp or juice. Liquid concentrate can be added directly to the juice.

[2] Other fuels such as charcoal are less easily controllable and cannot quickly provide the increased heating.

The type of pectin used in jams and marmalades (above 55% solids) is known as high methoxyl (HM) pectin. It is used in a pH range of 2.0-3.5. A second type, known as low methoxyl (LM) pectin, is used mainly for spreads or for gelling agents in milk products. There are a large number of different types of HM pectin, such as 'rapid set' and 'slow set' and it is necessary to specify carefully the type required when ordering pectin from a supplier.

Jams should be hot filled (at around 85^{o}C) into glass jars and sealed with a new lid. If the temperature is too high, steam condenses to water on the inside of the lid and dilutes sugar at the surface of the jam, which can cause mould growth. If the temperature is too low, the jam thickens and is difficult to pour into containers. Jars should be filled to approximately 9/10^{ths} full, to help a vacuum to form in the space above the product as it cools. The jars re kept upright during cooling until the gel has formed. The problems of obtaining glass jars in Uganda have led some producers to use plastic tubs, but these are not easy to hot-fill because they melt and the lid seals are often not good enough to prevent product leaking out and attracting insects.

Mixed fruit jam

Orange marmalade

Table 4.9. Process for jam, jelly or marmalade

Stage In Process		Notes
Fruit ↓		Mature but not over-ripe fruit without mould growth, picked carefully to reduce puncturing, splitting or bruising etc. Transport in stackable boxes to avoid crushing.
Inspect ↓		Remove mouldy, rotten, and badly damaged fruit. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks and stones. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
Wash ↓		Use clean, potable water in a wash tank to remove surface contaminants, e.g., pesticide residues, insects, soil or dirt.
Sort/grade ↓		Sort by hand on a sorting table to get similar colour or maturity. Shape and size are not important. Remove unwanted parts
Peel ↓	← Pulp/ core/ chop	Depending on the fruit, peels are removed by hand using sharp stainless steel knives or small peeling machines. Manual or motorised corers are available for pineapples. Other fruits are chopped into large pieces for boiling. Small fruits (e.g. strawberries or other berries) may be used whole. Pulper-finishers are suitable for soft fruits and separate pulp from skins and seeds. Check that all traces of peel are removed
	← Filter	For clear jellies and marmalades
Mix ↓		Add approximately equal weight of sugar to weight of fruit and if required, citric acid to obtain pH 3.0-3.3, (pH meter optional) and any extra pectin required. For marmalade, add thinly sliced citrus peels that have been boiled in 60% sugar syrup for 15 minutes and stored for at least 24 hours before use. Check thickness of peels. A preservative, such as 1.8% sodium benzoate is optional.
Heat ↓		To 104-105^{o}C in a stainless steel boiling pan for 15-20 mins., or until the solids content reaches 68-70%, measure by refractometer. Check temperature and time of boiling. Check to ensure that colour does not darken excessively.
Fill & Seal ↓		Hot-fill into pre-sterilised jars (boiled in water or in an oven at 100^{o}C for 10-15 mins) or in plastic pots or sachets if they can be sealed against insects. Seal and check fill- weight and seals. Re-used bottles should be carefully washed using detergent and thoroughly rinsed. An optional bottle rinser can be used to save time.
Cool ↓		To room temperature, upright on a table or using a bottle cooler (optional).
Label ↓		By hand or with label applicator. Check that the correct label is used and that label quality is satisfactory. Check that each one is correctly aligned.
Store		Store in cool dry place away from sunlight

Table 4.10 Common faults in jam making

Fault	Possible cause	Prevention
1 Gel does not set or is not firm	Incorrect pectin type Too little pectin Solids content too low Incorrect pH value Pectin not fully dissolved Boiling for too long Pectin solution too old Pre-setting Holding at high temperature for too long (pan too big)	Select correct type of pectin Check formulation Add more sugar Check pH, adjust with citric acid Mix with sugar before dissolving Produce smaller batches Use new stock Increase filling temperature Lower filling temperature, make smaller batches or use slow-setting pectin.
2 Gel too firm	Too much pectin Solids content too high pH too low	Check formulation Heat less, add less sugar or add more water Adjust pH
3 Pre-setting	Filling temperature too low Filling time too long Solids content too high pH too low	Increase filling temperature or choose slow-setting pectin Produce smaller batches or use slow-setting pectin See above See above
4 Fruit floats	Filling temperature too high Pectin sets too slowly, gel not strong enough Solids content too low, giving slow setting pH too high, giving slow setting	Lower filling temperature Choose rapid-set pectin See above Adjust pH
5 Syneresis (cracked gel with oozing liquid)	Pre-setting due to low filling temperature pH too low Solids content in fruit and in gel are different	See above Adjust pH Pre-mix fruit and sugar syrup and hold overnight or cook longer

Pickles and salted vegetables

There are a wide variety of pickled vegetables, but they are not commonly eaten in Uganda, except by expatriates and within the Asian community. Different types include:

1) *fermented pickle*, made by submerging vegetables in a dilute brine (2-5% salt). Naturally occurring bacteria grow over 1-2 weeks to produce lactic acid, which then prevents the growth of food poisoning bacteria and other spoilage micro-organisms. The amount of added salt controls the type and rate of the fermentation. Sugar (2-5%) can be added to increase the rate of fermentation or to make the product sweeter.
2) *'salt stock' pickle* is produced using a more concentrated brine (up to 16% salt), and is preserved by the salt and not by fermentation. Fruits and vegetables can be preserved in this way to spread production throughout the year.
3) vegetables may be packed in vinegar (acetic acid), salt and sometimes added sugar to produce a variety of pickled products that have a different flavour and texture to fermented pickles. They are usually pasteurised by heating.
4) *Sweet pickles* are made from fruits or mixtures of fruits and vegetables. They are preserved by a combination of lactic or acetic acid, sugar and spices.
5) *Salted vegetables* are made in a sealed drum by building up alternate layers of chopped or shredded vegetable such as cabbage, with layers of salt. The salt draws out water from the vegetables to form concentrated brine. The products are washed to reduce the high levels of salt before they are eaten.

The pickle should be covered at all times during production to stop insects from contaminating it with moulds and yeasts, which spoil the product during storage. Glass jars are the most common packaging. Sealed polythene bags or plastic pots can also be used provided that they can be properly sealed to avoid leakage of product, which damages paper labels and attracts insects.

Table 4.11. Process for pickles

Stage In Process		Notes
Essential	**Alternative**	
Vegetable or fruit		Cucumber, cabbage, courgette, olive, or other types of vegetable, picked carefully to reduce splitting or bruising. Check for full maturity but not over-ripe.
Inspect ▼		Remove mouldy, rotten, and badly damaged fruits and vegetables. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks, stones and rocks. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
Wash ▼		Use clean water in a wash tank to remove surface contaminants, e.g., pesticide residue, stones, leaves, insects, soil or dirt, etc.
Sort/grade ▼		Sort by hand on a sorting table to get similar colour, size, shape or maturity. Remove discoloured leaves, stems or other unwanted parts
◄	Peel	Most fruits and vegetables do not require peeling, but some pickles have peeled fruits. Peel by hand using sharp stainless steel knives or small peeling machines. Check that all traces of peel are removed
▼ ◄	Cut/slice/ core	Cucumber, okra or courgette are often pickled whole. Olives are pitted (the stone is removed), limes are sliced into halves or quarters and cabbage is cut into thin strips using stainless steel knives. Cutting allows faster penetration of pickling liquor. Check for uniform sized pieces to allow uniform penetration of salt.
Mix ▼		In food grade plastic tank, different mixtures of salt, sugar, vinegar and spices depending upon local tastes and the product requirements. Check weights of ingredients with scales (pH meter, brine hydrometer optional)
◄	Ferment	Natural fermentation for 3-7 days or up to 18 months depending on the product. Check for contamination by insects, especially ants, which can introduce yeasts or moulds. Check time and temperature of fermentation.
▼ ◄	Heat	Pasteurise for 10-15 mins at 90-100^{o}C in a stainless steel boiling pan.
Fill & Seal ▼		Pack into pre-sterilised jars (boiled in water or in an oven at 100^{o}C for 10 - 15 mins). Fill with hot brine/ vinegar to cover the vegetables. Seal and check fill-weight and seals. Re-used jars should be carefully washed using detergent and thoroughly rinsed. An optional bottle rinser can be used to save time. If jars are not obtainable, plastic pots or bags can be used, provided that they can be adequately sealed against insects.
Cool ▼		To room temperature, either by lying jars on their side on a table or using a bottle cooler (optional).
Label ▼		By hand or with label applicator. Check that the correct label is used and that label quality is satisfactory. Check that each one is correctly aligned.
Store		Store in cool dry place away from sunlight

Pastes and purees

Pastes and purees can be made from any fruit or vegetable, but the most common types in Uganda are tomato and garlic pastes, which are used in cooking. They are made by mashing any fruit or vegetable to a smooth, thick consistency and then carefully boiling this puree to evaporate the water with constant stirring to prevent burning. The concentration of solids in the final product is normally around 36%. This high solids content and the natural acidity preserve the product for several days, but they should be pasteurised for a longer shelf life.

An alternative method for producing tomato paste is to hang the pulp in a sterilised cotton sack for an hour. The watery juice drains out and the pulp loses up to half its weight. 2.5% salt is mixed into the concentrate and it is re-hung for a further hour, during which time the weight falls to one third of the original. The product can then be packaged and pasteurised or further concentrated by heating. This product has a more natural flavour and uses much less fuel than boiling.

Products that may have a demand in future

Bottled fruits

The main reasons that bottled fruits are not produced in Uganda are the difficulties in obtaining glass bottles and the lack of demand for the products. However, bottling has advantages over drying or freezing in that fruits with a recognisable shape, colour, flavour and texture can be preserved for many months at room temperatures and require no further preparation before consumption. Bottles are available from Kenya or South Africa, but they are expensive and suffer breakage during road transport if not properly packed.

Fruits are filled into jars, sealed and heated to destroy enzymes and micro-organisms. The time and temperature of heating must be carefully controlled. If fruits are over-processed, they lose much of their texture, colour, vitamins and flavour and are not saleable. The correct heating conditions depend on the type of fruit, the size and shape of the bottle and the size of the fruit pieces. A food technologist or microbiologist should be consulted to advise on the correct processing times. The sealed containers prevent attack by insects, birds etc., prevent re-contamination by micro-organisms and exclude air and (for some) light. It is not recommended that vegetables are processed in this way unless they are first acidified. The low levels of acid in vegetables mean that if they are not heated sufficiently, there is a risk of serious food poisoning and even death from a type of micro-organism named *Clostridium botulinum* (see also Annex B).

Fruit is normally packed into jars with one of three grades of sugar syrup (Table 4.12).

Table 4.12. Sugar syrups for bottling fruits

Type of syrup	Amount of sugar (g/litre)
Light syrup	200
Medium syrup	400-600
Heavy syrup	800

Table 4.13. Process for bottled fruits

Stage In Process	Notes
Fruit ▼	Mature but not over-ripe fruits,, harvested as carefully as possible to reduce bruising etc.
Inspect ▼	Remove mouldy, rotten, and badly damaged fruit. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks, stones and rocks. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products.
Wash ▼	Use clean, potable water in wash tanks to remove surface contaminants, e.g., pesticide residues, insects, or soil
Sort/ Grade ▼	Use a sorting table to sort for uniform size, colour and maturity. This is essential to produce uniform quality products.
Peel ▼	Usually done by hand using sharp stainless steel knives, but small peeling machines are available for some types of fruits. Check that all traces of peel are removed.
Cut/slice/core ▼	To uniform sized pieces able to fit into jars. Depending on the size of the pieces and scale of operation, use knives, corers, fruit choppers, cutters, slicing or dicing machines. Check for uniform sized pieces.
Acid dip ▼	(optional) dip in 2% citric acid, lemon or lime juice for 5-10 mins. to prevent browning of light coloured fruits.
Heat sugar Syrup ▼	Use weighing scales or scoops, heater, filter bag, thermometer, (refractometer optional). Filter through a fine muslin bag. Check syrup concentration and temperature (90-100^{o}C).
Fill & Seal ▼	Fill fruit into hot jars (jars should be heated in boiling water or an oven at 100^{o}C for 10-15 mins.). Add hot sugar syrup. Check for correct fill-weight and properly sealed lid. Re-used jars should be carefully washed using detergent and thoroughly rinsed. An optional bottle rinser can be used to save time.
Pasteurise ▼	Heat bottles in gently boiling water (90-100^{o}C) for 10-20 mins, depending on size of the jar. Check temperature and time of heating.
Cool ▼	To room temperature, either by lying bottles on their side on a table or using a bottle cooler (optional).
Label ▼	By hand or with label applicator. Check that the correct label is used and that label quality is satisfactory. Check that each one is correctly aligned.
Store	Store in cool dry place away from sunlight.

Crystallised fruits, fruit leathers and cheeses

These products are largely unknown in Uganda, but may have good potential for a number of reasons:

1. The expansion of the bakery industry may create a demand for new ingredients for cakes etc., particularly because raisins and sultanas are imported and are relatively expensive
2. There is a growing consciousness over the negative effects of sugar confectionery on dental health and at present there are few alternatives for concerned parents to give to their children. These products would be more acceptable healthy alternatives
3. There is a growing international demand for dried fruits and the abundant supply of fruit in Uganda could be tapped to create new products for this market, including organic fruit leathers and crystallised fruits
4. The technology is simple and low cost sugar is readily available.

Crystallised fruits

Crystallised fruits, fruit peels (for marmalades or use in cakes) and osmotically dried fruits (known as 'osmasol' products when dried in a solar dryer) are fruit pieces that are soaked in hot concentrated sugar syrups to extract some of the water before drying. They have a natural colour but a sweeter, blander taste than the fresh fruit because natural acids are removed and sugar is added during the process. The lower acidity may allow mould growth if the fruit is not properly dried and packaged. This process is also used to part-process fruits so that production can be carried on throughout the year. The single soaking described in Table 4.14 may produce a product that has a tough texture. Successive soaking in syrups of increasing strengths can make a softer dried fruit. The fruit is first boiled in 20% syrup and soaked overnight. It is then moved into 40% and then 60% syrups on successive days, boiling for 5-10 minutes at each transfer, depending on the hardness of the fruit. Because the syrup becomes more dilute as it extracts water from the fruit, a 60% syrup can be used the next day as a 40% syrup and a new 60% syrup made up. The 40% syrup becomes a 20% syrup next day and the 20% syrup is either discarded or used to make wine. The concentration of syrups can be checked using a refractometer.

Fruit 'leathers'

These products are made from fruit pulp that is dried in a thin layer to produce a sheet that has a texture resembling leather. The sheets may be stored by wrapping them in alternate layers with polythene. Sheets can be cut into small pieces using either knives or biscuit cutters to form different shapes, which can be sold as confectionery or as alternatives to dried fruit for cake making. If different coloured fruits are dried into sheets of leather and then pressed together, they form a multi-layered 'sandwich' of thin coloured layers, which is an attractive confectionery product.

Fruit 'cheeses'

Fruit cheeses are pulps that are boiled until they have a final sugar content of 75-85%. When they cool, they set as a solid block and can be cut into bars or cubes to eat directly as confectionery, or they can be used in small pieces in bakery products.

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Table 4.14. Process for crystallised fruits fruit leathers or fruit cheeses

Stage In Process		Notes
Essential	**Optional**	
Fruit ↓		Harvest as carefully as possible to reduce bruising and other damage.
Inspect ↓		Remove mouldy, rotten, and badly damaged fruit. Also remove all visible foreign material (physical contaminants): leaves, stems, stalks, sticks, stones and rocks. Poor quality raw materials produce poor quality, and perhaps unsafe, finished products
Wash ↓		Use wash tanks or special washers with clean, potable water to remove surface contaminants, e.g., pesticide residues, insects, dirt or soil, etc.
Sort/ grade ↓		By hand to pick out contaminants and select fruits with the same colour and maturity (fully mature but not over-ripe. Over-ripe fruits are easily damaged and difficult to dry). Under-ripe fruits have poorer flavour, colour and appearance. For crystallised fruits, uniform size and maturity are important to get uniform drying times for the pieces.
Peel ↓		By hand using knives or peelers, or using small peeling machines. Check that all traces of peel are removed
←	Treatment with sulphur dioxide	This is optional to reduce browning, using a food-grade plastic tank for sodium sulphite dip. Other equipment includes weighing scales or scoops. Check concentration of sulphite and time of dipping. **Safety: do not breathe fumes. Sulphur dioxide causes coughing and eye irritation**.
←	Pulp	For fruit leathers and cheeses, using pulpers, liquidisers, steamers or pulper-finishers. Check for a uniform pulp containing no fruit pieces.
←	Syruping	For crystallised fruits or peels for marmalade. Fruit is boiled in 60% sugar syrup for 10-15 mins. and then soaked in the syrup for 12-18 hours (see text). Check syrup concentration and temperature. Equipment includes weighing scales or scoops, boiling pan, heater, food-grade tank and muslin cloth filter. A refractometer is optional.
←	Dry	For leathers, the pulp is spread on polythene sheets to dry in a solar dryer. Crystallised fruits are dried in a similar way to fresh fruits (see Section 4.3.2). The time needed for drying depends on the temperature, humidity and speed of the air, the type of dryer and the size of the food pieces or thickness of the layer of pulp. Check the temperature and time of drying, check for mould growth and insect contamination.
←	Boil	For fruit cheeses, boil gently until the pulp thickens. The solids content can be checked by refractometer.
Pack ↓		Using an electric heat sealer for moisture-proof, airtight plastic bags. Check fill-weight and seal.
Label ↓		Check that label is correct for type of product.
Store		Store in a cool dry place away from sunlight.

Checklist 4

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer

Question	Tick	Notes
1. Do you know how to correctly prepare raw materials and process and pack the following products?		
• Bottled fruits		
• Chutneys		
• Crystallised fruits		
• Dried fruits and vegetables		
• Fried products		
• Fruit cheeses		
• Fruit leathers		
• Jams, jellies and marmalades		
• Juices squashes and cordials		
• Pastes and purees		
• Pickles and salted vegetables		
• Sauces		
• Wines		
2. Do you know which of the above products have an increasing demand?		

5 Fruit and Vegetable Processing Equipment

The equipment required for fruit and vegetable processing is described in the following section. A summary of the spare parts, maintenance and cleaning requirements is shown in Table 5.1. Details are given below for individual items of equipment.

Table 5.1, Summary of spare parts and maintenance/cleaning requirements for fruit and vegetable processing equipment

Type of equipment	Spare parts kept in stock	Maintenance required	Cleaning
Airlocks	None	None	After use with detergent and clean water, followed by sterilisation using dilute bleach
Blanchers	None	None	Daily after use with detergent and clean water
Boiling pans/ pasteurisers	None	None	Daily after use with detergent and clean water
Bottle coolers	None	None	Weekly wipe with damp cloth
Bottle washers	None	None	Weekly wipe with damp cloth
Bottlebrush	None	None	None
Corers	Replacement blade	None	Daily after use with detergent and clean water
Corkers	None	None	Weekly, wipe with damp cloth
Crown cappers	None	None	Weekly, wipe with damp cloth
Cutting boards	None	None	Daily after use with detergent and clean water
Deep fat fryers	Electric heating element (electric versions)	Periodic check of temperature and thermostat setting	Periodic (monthly) removal of oil and cleaning
Dicers	Replacement blade	Periodic blade sharpening	Daily after use with detergent and clean water
Dryers	Plastic covers, preferably UV resistant	Replace polythene cover each year or replace polyester cover every 3-5 years	Cleaning trays after use with detergent and clean water
Energy saving charcoal stove	None	None	Clean out ashes daily
Fermentation tanks	None	None	After use with detergent and clean water, followed by sterilisation using dilute bleach

Type of equipment	Spare parts	Maintenance required	Cleaning
Fillers	None	None	After use with detergent and clean water
Filters (wine, juice)	Filter cloths or pads	None	After use with detergent and clean water, followed by sterilisation using dilute bleach
Food grade drums	None	None	After use with detergent and clean water, followed by sterilisation using dilute bleach
Freezer	None	Periodic de-icing	Periodic cleaning with detergent and clean water after de-icing
Fruit crushers	Motor drive belt, bolts, fuse	Monthly check belt tension, bearings, condition of wiring and bolt threads	After use with detergent and clean water
Fruit presses	None	Periodic check for wear on screw and bearing	After use with detergent and clean water
Gas burners Gas cylinder	None	None	After use with detergent and clean water
General tools, work tables	None	None	After use with detergent and clean water
Heat sealers	Heating element	None	Weekly wipe with damp cloth. Remove any burned-on plastic immediately
Hosepipe and spray gun	Washer for spray gun	None	Weekly wipe with damp cloth.
Hydrometers – alcohol and brine	None	None	After use with detergent and clean water
Insect proof door	None	None	Weekly wipe with damp cloth.
Insulated filling tank	None	Periodic check on accuracy of temperature gauge	After use with detergent and clean water, followed by sterilisation using dilute bleach
Jam thermometer	None	None	Carefully wipe with a clean cloth
Labellers	None	Daily, check guide position	Daily - wipe down surface with damp cloth
Laboratory glassware & equipment	None	None	After use with detergent and clean water, rinse with distilled water
Liquidisers	Fuse	Monthly, check bearing tightness. Periodic blade sharpening	After use with detergent and clean water
Motor, isolator, and starter	None	Weekly check on wiring and bearings	Weekly wipe down with clean cloth

Type of equipment	Spare parts	Maintenance required	Cleaning
Packing table	None	None	After use with detergent and clean water
Pasteurising kettle	None	None	After use with detergent and clean water
Peelers	Replacement blade	None	After use with detergent and clean water
pH meters	Buffer solutions, probe	Monthly standardisation	Wipe carefully with damp cloth after use
Pot sealers	Heating element	None	Weekly wipe with damp cloth
Preparation table	None	None	After use with detergent and clean water
Pressure cooker	None	None	After use with detergent and clean water
Protective gloves, hats, hairnets, coats, boots	None	None	Weekly laundry for coats, daily washing of boots. Others laundry as required
Pulper finishers	Motor drive belt, bolts, fuse	Monthly check belt tension, bearings, condition of wiring and bolt threads	After use with detergent and clean water, with particular attention to the screen
Reamers	None	None	After use with detergent and clean water
Refracto-meters	None	None	Wipe carefully with tissue paper and rinse with distilled water
Scales	None	Monthly standardisation with known weights	Weekly wipe with damp cloth
Sulphuring cabinet	None	None	Clean trays after each batch with detergent and clean water

Airlocks

Fig 5.1 Airlocks

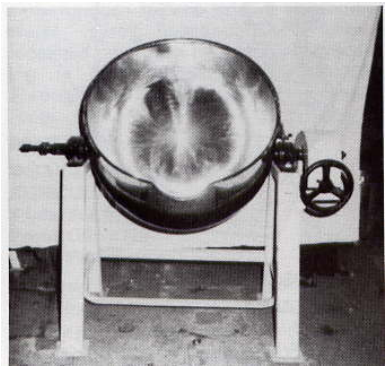
Airlocks can be imported or made locally from glass tube. They are filled with sodium metabisulphite solution and prevent air from entering the fermentation tank and spoiling the wine fermentation. It is important to ensure that they are thoroughly cleaned with detergent and sterilised with bleach before use with a new batch of wine.

Blanchers

Hot water blanchers are boiling pans that are used mainly for vegetables. These are less acidic than fruits and therefore the pan can be made from aluminium. A mesh scoop is used to remove the hot vegetables. Steam blanchers use the same pans and have a removable mesh base to hold the vegetables above the boiling water. There is no maintenance required and pans should be cleaned with detergent and rinsed with clean water after use.

Boiling pans/pasteurizers

Fig 5.2. Boiling pan/pasteuriser



There are two types of boiling pans: at smaller scales of operation, a simple stainless steel (or less desirably aluminium) pan can be placed directly over the heat source. However, viscous products such as sauces, syrups, jams and chutneys, are likely to burn onto this type of pan unless great care is taken to control the heat and thoroughly stir the mixture as it is being heated. This reduces the quality of the product and also significantly slows down production because the pan must be cleaned between batches. At a larger scale, a 'double jacketed' stainless steel boiling pan is needed. Steam is produced in the space between the outer jacket and inner pan to give more uniform heating and avoid localised burning of the product. These are expensive to import and local fabrication in Uganda is difficult because the skills and facilities for welding stainless steel are available in only a few workshops (see UNIDO Food Processing Equipment Directory).

There is no routine maintenance or requirement for spare parts. Pans should be thoroughly cleaned using detergent, ensuring that all burned-on food is removed before rinsing with clean water.

The most appropriate type of heater depends on the cost and availability of different fuels in a particular area. In urban centres, gas or electricity is the preferred options because there is no risk of contamination of the product. In rural areas, these may not be sufficiently available or reliable and other types of fuel (e.g. charcoal or kerosene) have to be considered.

Bottle coolers

Fig 5.3 Bottle cooler

These are used to increase the rate at which glass containers cool, by allowing the containers to pass through an inclined water bath. There is a flow of cooling water in the opposite direction to the containers. No spare parts are required and no maintenance, except periodic emptying and cleaning to prevent a build-up of micro-organisms in the cooling water. If the quality of water is in doubt, it should be chlorinated.

Bottle washers

The time consuming part of bottle washing is rinsing out the detergent and bottle washers are used to reduce this time. They are made by soldering vertical pipes onto a larger base pipe and connecting the base pipe to a water supply. In use the bottles or jars are inverted over the vertical pipes and rinsed until free of detergent. No spare parts are required and there is no maintenance requirement,

Fig 5.4 Bottle Washer

Capsule sealer

Fig 5.5 Capsule sealer

The machine heats plastic capsules that are used as a tamper-evident seal on bottles. In operation the thermostatically controlled machine is switched on and allowed to heat up. A bottle is placed on the tray with the capsule inside the heating element until the capsule has shrunk and sealed (a few seconds).

There are no maintenance requirements and no spare parts. The machine should be cleaned weekly by wiping it with a damp cloth when it is cold

Corers

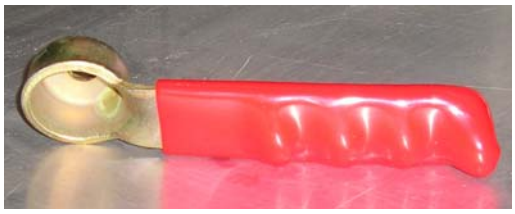
The core of pineapples is removed before the fruit is bottled or dried. Manual corers are available from Kenya and motorised versions are also available, but are expensive. Corers are not required when pineapples are processed for juice or pulp and the whole fruit is pulped. They should be cleaned after use, using detergent and rinsing with clean water. There are no spare parts or maintenance requirements, except periodic sharpening of the blades when they become blunt.

Corkers

A corking machine compresses the cork and inserts it into the bottle. These machines are imported from Europe or South Africa. In operation a cork is inserted into hole in the top of the machine and a bottle is held in place by the sprung stand. The lever is then lowered to force the cork into the bottle. There are no spare parts and provided the mechanism is kept clean, there is no routine maintenance. The machine should be wiped clean each week.

Fig 5.6 Corking machine

Crown cappers



A hand operated Crown capper is a simple die that is placed over the cap on a bottle and is then struck with a hammer to seal it. Another design has two handles that are lowered to force the cap onto the bottle. Neither design requires spare parts or maintenance requirements apart from being kept clean.

Fig 5.7 Crown capper

Cutting boards

These are made from food grade nylon and are designed to withstand cutting by knives. They have no maintenance requirement, but should be washed after use using detergent and rinsed with clean water. Over time, knives damage the surface and the board becomes difficult to clean. It should then be replaced.

Deep fat fryers

Fig. 5.8 Deep fat fryer

The simplest fryer is a pan of oil over a fire, but there is little temperature control and a risk of burning both the oil and the product. The equipment supplied is a more sophisticated version of this for use in rural areas.

Warning:
The equipment does not control the temperature of the oil.
There is a risk of fire if it is allowed to become too hot.

Thermostatically controlled electric deep fat fryers overcome these problems. They can be imported or made by local workshops. The fuel-fired fryer has no maintenance requirement and no spare parts. When the oil becomes darkened it should be emptied, cleaned with detergent and rinsed with clean water.

Dicers

Manual dicing machines first cut the material into strips and these are then cut into cubes. The machines produce uniform sized cubes, which are difficult to achieve using a knife. They should be washed with detergent after use and rinsed with clean water. The blade should be sharpened as needed.

Dryers

Sun drying has low capital and operating costs. But problems include contamination of the products by dust, birds, rats or insects, slow drying and no protection from rain or dew, which encourages mould growth. There is little control over the drying conditions and products have variable quality. Provided that they are correctly designed, solar dryers have faster drying rates than sun drying because the air is heated to 10-30^{o}C above the ambient air temperature. This also reduces its humidity and deters insects.

Fig 5.9 Solar dryer

Faster drying increases the throughput, reduces the risk of spoilage and improves the product quality. However, if fruits are dried too rapidly, this can result in ‘case hardening’ (see glossary in Annex C) and mould growth. Drying rates are reduced on cloudy days and dryers cannot be used at night. To overcome these problems a heater can be fitted to the drying tunnel, but this increases both capital and operating costs.

The size and type of dryer depends on the anticipated production level, the amount of investment that can be afforded and the expected profitability of the business. There are very many different types of dryers and it is not possible to describe each in detail in a manual of this type. Design considerations are described in books listed in Annex A. The size of dryer needed to dry a given weight of food per day can be calculated by assuming the following drying areas for different types of product:

- $1m^2$ is needed for around 2 kg of less dense products such as shredded cabbage
- $1m^2$ is needed for around 4 kg of moderate density products and
- $1m^2$ is needed for up to 6 kg of chopped fruits.

Solar dryers do not require spare parts or routine maintenance. However, ultra-violet light causes the plastic sheeting to deteriorate and it must be replaced periodically depending on the type of plastic used and the strength of the sunlight. Polythene needs replacing each year, UV resistant polythene and polyester every 2-3 years and UV-resistant polyester every 3-5 years. Drying trays should be washed using detergent and rinsed with clean water after each use.

Fermentation tanks/food grade drums

Fermentation tanks should be made from food grade plastic or stainless steel and not from black or yellow plastic water containers. (These have pigments and plasticizers that could contaminate the wine). Imported food grade containers are available from agents in Kampala (see Food Processing Equipment Directory). Tanks and drums should have a wide neck that allows easy access for cleaning. A hole should be drilled into the screw-on lid to fit a bung and airlock. There are no spare parts or maintenance requirements. The tanks or drums should be thoroughly scrubbed with detergent after use, rinsed with clean water and then sterilised with bleach. They should be fully dried before re-use. Food grade drums can also be used to store part-processed fruits for later processing.

Fillers/Insulated filling tanks

At a small scale, solid and viscous products (such as pickles, jams or chutneys) are filled by hand using jugs, funnels, scoops or ladles. Liquid products can be filled using small gravity fillers, made by fitting a tap to a stainless steel or food grade plastic tank. A ‘gate valve’ should be used and not domestic taps because these are difficult to clean properly. Three or four valves can be fitted to a tank to enable several workers to fill containers at the same time. Volumetric dispensers have a piston that measures out the same amount of liquid into each container. The insulated filling tanks supplied by the project will keep juice hot for hot-filling.


Fig. 5.10 Insulated filling tank

Fillers have no spare parts or maintenance requirements. Tanks should be cleaned after use by washing thoroughly with detergent and rinsing with clean water. Care is needed to ensure that the taps are properly cleaned, in order to prevent contamination of the next batch.

Filters

Filters for juices, wines etc. are bags made from muslin or fine cotton cloth. They should be sterilised each day by boiling for 10-15 mins and fully dried by hanging in sunlight. Specialist wine filters that use a filter agent such as bentonite, perlite or isinglass can be imported. These are either gravity filters or pressure filters. Pressure filters have the higher throughput. Gravity filters should have spare bags and pressure filters should have a spare washer for the pump and spare filter pads. Gravity filters have no maintenance requirements, but the pump on pressure filters should be kept lubricated with a thin film of edible oil. It is important that no dust or grit is allowed to get into the pump as this will rapidly wear out the washer.

To filter wine, one or all of the following filter agents can be used: a dessertspoonful per 1 gallon (5 litres) of bentonite is first sprinkled on the surface and the wine is allowed to stand. Then a cupful of wine is mixed with 2 dessertspoonfuls of perlite and returned to the wine. Finally, one dessertspoonful of isinglass is sprinkled over the surface of the wine. It should be stirred gently to mix the clearing agents without disturbing the sediment. The wine should be kept covered while it is clearing (for 30-60 mins for most wines, but some may take longer). If a haze remains in the wine, it may be necessary to use a peptic enzyme to remove the pectin haze (see Section 6.1.4).

When using the gravity filter, the bag is placed inside the bucket provided and wine is poured in. At first the wine remains cloudy as it emerges from the filter and this should be collected and later returned to the filter. After a short time the filter bag becomes coated inside with sediment and the wine emerges clear. This should be collected in another clean container. The bucket should be kept full by occasionally topping it up with wine, but it can be left unattended at other times.

When using the pressure filter, the pads are placed into the filter frame and it is closed. The plastic pipe work is connected to the filter frame and the pump, with the outlet pipe draining into a clean container. The pump is filled with wine and the top is closed. The pumping action then forces wine through the filter pads and clear wine is collected in the container.

Freezers

Deep freezers require periodic de-icing and the opportunity should be taken at this time to clean the internal surfaces. There are no spare parts or other maintenance requirements.

Fruit crushers

Powered machines that are used to crush pineapples or other hard fruits consist of a rotating screw inside a casing. The casing has a screen in the base. Juice/pulp drains from an outlet in the base of the casing and skin is ejected from the end of the casing down a chute. The casing should be fitted with wing nuts to remove it easily.

In operation, pineapples are cut into large pieces and fed into the hopper. Routine maintenance consists of: weekly checks on the belt tension (maximum 2cm sideways movement midway along the belt) weekly checks of electrical connections monthly greasing of bearings. A spare drive belt and fuse should be kept.

Fig. 5.11 Pineapple crusher

Crushers should be cleaned after use as follows:

1. Remove the hopper and wash with detergent. Rinse with clean water and allow to dry.
2. Remove the casing and wash as for the hopper.
3. Wash the screw and screen thoroughly, using a brush and detergent. Rinse with clean water.
4. Clean the chute and juice/pulp pipe with a water hosepipe and spray gun.
5. Ensure that no particles of fruit remain in the machine after cleaning

.

Important: This machine is not fitted with safety devices to stop the motor if it is opened. Ensure that the machine is isolated from the mains electricity supply before dismantling it for cleaning or maintenance

Fruit presses

Fig. 5.12 Fruit press

Manual fruit presses have a stainless steel cage in which a press plate is raised and lowered by a screw. The screw should be made from a harder grade of steel than the bearing to prevent the more expensive screw from wearing down (the bearing can be replaced more cheaply than the screw). Layer plates made from stainless steel, nylon or painted mild steel may be needed in larger presses to promote efficient pressing.

In operation a muslin or cotton bag is placed in the cage and pulp is poured in. The bag is closed and the press plate is lowered. After a few minutes, additional turns of the screw increase the pressure further. Juice is collected via a pipe. The screw is then raised and the bag is removed.

There are no spares and no routine maintenance. To clean the press, the cage is removed and brushed thoroughly with detergent and rinsed with clean water. The other components

are cleaned while the cage is removed. The press bags should be cleaned with detergent and then sterilised by boiling for 10-15 minutes before drying in the sun.

Gas burners/cylinders/regulators

The burner is connected to the cylinder using special orange rubber gas pipe and a regulator. The 'Jubilee' screw fittings that connect the pipe should be tightened as much as possible and the joints should be tested by applying detergent and switching on the gas supply. Any sign of bubbles in the detergent should be investigated and the leak corrected. Care should also be taken not to damage the gas pipe by placing heavy objects on it or allowing it to get too close to the burner. There are no spare parts and no routine maintenance. The manufacturer has set the regulator and it should not be adjusted under any circumstances. If the gas flow becomes insufficient (and there is gas in the cylinder), a competent gas engineer from one of the gas supply companies should be called to correct the problem. The burner should be cleaned after use and when it is cool by wiping it with a damp cloth, ensuring that any food residues are removed.

General tools, work tables

Basic equipment such as buckets, tables, stainless steel knives etc., is used to prepare raw materials. Aluminium or stainless steel sheet is the preferred material for the surface of work tables. Any parts of equipment that are in contact with acidic fruits (e.g. boiling pans) should be made from stainless steel or less desirably, aluminium. Other metals should not be used because they react with the fruit and cause off-flavours or colour changes in the product. Food grade plastic should be used for all containers, rather than the yellow plastic containers that are widely available. Suppliers of utensils, food grade plastic vessels and metal tables are given in the UNIDO Food Processing Equipment Directory. There are no spare parts and no routine maintenance requirements. All tools and tables should be washed with detergent after use and rinsed with clean water.

Heat sealers

These machines simultaneously melt and press plastic to weld two layers together, thus sealing a bag. A small bulb lights when the bar is pressed down and the bar should be released about one second after the light goes out (to allow the film to cool). The manufacturer's recommended settings are shown in Table 5.2. To find the correct setting, the control should be set at the minimum number and the sealer used to seal a bag. If no seal is formed, the control should be set to a higher number and re-tested. This should be repeated until a strong seal is formed. If the plastic burns or holes are formed in the seal the setting should be reduced.

Fig 5.13 Heat sealer

A relatively wide seal (e.g. 3-5 mm) is required for dried and liquid foods and bar-type sealers are preferable to wire-types. Care should be taken to ensure that there is no product on the inside of the film where the seal is to be made, as this will prevent proper sealing. A sealing wire should be held as a spare. There is no routine maintenance and the sealer should be wiped clean weekly. Any burned-on plastic should be removed immediately by wiping the Teflon cloth and sealing bar using a cloth dampened with a suitable solvent (e.g. kerosene). If the Teflon cloth is torn, it should be replaced immediately because a torn cloth

will short-circuit the heating element and damage it. The machine can be left plugged into the electric socket because it only uses power when the bar is pressed down.

Table 5.2 Heat sealer settings

Setting	Polythene	Polypropylene and other high-heat films
1	Less than 0.06 mm	
2	Less than 0.10 mm	
3	Less than 0.14 mm	
4	Less than 0.20 mm	Less than 0.030 mm
5		Less than 0.044 mm
6		Less than 0.06 mm
7		Less than 0.08 mm

(Source: Manufacturer's data)

Hosepipes and spray guns

The hose is used to wash down equipment, floors etc. The spray gun is adjustable and can spray a single jet or a wide spray. No spare parts or routine maintenance are required and the hose and gun should be cleaned weekly by wiping it with a damp cloth.

Fig. 5.14 Spray gun

Hydrometers – alcohol and brine

This is a graduated glass tube that floats in a sample of liquid (e.g. wine or brine) in a measuring cylinder. Different types are used to measure sugar, alcohol or salt concentration, by measuring the Specific Gravity of the liquid. Spin the hydrometer gently to remove any air bubbles on the surface.

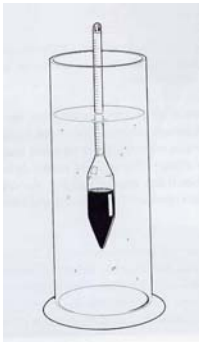


Fig 5.15 Hydrometer

When the hydrometer has stopped moving and it is not touching cylinder, take a reading where the underside of the liquid surface touches the graduated scale on the tube. This figure is converted into alcohol or salt concentration, depending on which hydrometer is used, using a conversion table supplied with the hydrometer. The reading should be made at 20^{o}C, but no significant error occurs if the temperature of the liquid is +/- 5^{o}C of this. The specific gravity reading is used to calculate the % alcohol in wine or the salt concentration in brine (Section 5.17). There are no spare parts or routine maintenance. The hydrometer should be cleaned by rinsing it in clean water and then sterilised in dilute bleach.

The hydrometer is very fragile and should be handled carefully, stored in its protective case and not allowed to come into contact with hot water.

Jam thermometers

This is a special thermometer that has readings up to 120^{o}C and is strengthened to withstand sudden changes in temperature. It is inserted into boiling jam and the reading is used to determine when to stop boiling (Section 4.2.2). There are no spare parts or maintenance required. The thermometer should be cleaned by wiping it with a cloth when cool and then rinsing it in clean water.

Label applicators

A platform holds a stack of labels below an opening in the table, with the top label level with the surface. Glue is applied to the label and a round container is rolled over the opening and the label is picked up and pressed onto the container. The guide rails ensure that the label is applied in the same position on every container.

Laboratory glassware/equipment

The laboratory equipment used for testing fruit and vegetable products includes glass beakers, pipettes, flasks and a burette (pictured). Pipettes are used to suck a known volume of a chemical and drop it into a sample of juice. **Care is needed not to suck chemicals into the mouth.** The burette is used to accurately measure the amount of a chemical that is added to a sample of juice when testing the amount of acid in the juice (Section 6.1.1).

Glassware should be cleaned with detergent and bottle brushes, rinsed with clean water and then rinsed again with distilled water (distilled water can be obtained from vehicle servicing and spares companies, where it is used to top up batteries). There are no routine maintenance or spares required.

Fig. 5.16. Burette

Liquidisers

Domestic liquidisers are likely to be too small and not sufficiently robust for small scale processing. If they are used, a stock of spare drive pins should be kept, because these are sheared if the motor is overloaded. Larger industrial liquidisers can be imported. The liquidiser bowl should be cleaned with detergent after use and rinsed with clean water. Care is needed to avoid cuts from the liquidiser blade. The motor housing should be wiped clean with a damp cloth and care should be taken not to allow water to come into contact with the motor.

Motors/isolators/starters

A qualified electrician should wire electric motors. Motors should not be wired directly to 13 amp sockets and a starter and isolator should be fitted. When used, V-belts should be tightened to permit a maximum of 2cm sideways movement at the centre of the belt. There are no routine maintenance requirements, except to check that wiring a remains properly connected and does not work loose because of vibration. Motors, starters and isolators should be kept clean and the external surfaces should be wiped down weekly.

Always ensure that a motor is isolated from the mains before touching it for any reason. Do not use water to wash any electrical equipment.

Peelers

Manual peelers are available for round, thin-skinned fruits such as apples. Other more irregular shaped fruits are peeled by hand using a sharp stainless steel knife.

pH meters

Small hand-held pH meters are suitable for process control, but they are relatively expensive. They should be calibrated against buffer solutions that are supplied with the instrument and also calibrated for the ambient temperature. pH can also be measured using pH papers, which are cheaper but less accurate than meters.

Pot & bottle sealers/cappers

Twist-on-twist-off (TOTO) caps and plastic caps are usually fitted by hand. Small machines are available to seal Roll-On-Pilfer-Proof (ROPP) caps onto jars or bottles. A heat sealer for sealing foil or plastic lids onto plastic pots can be made using a domestic iron, held on a drill stand. Crown cappers and corkers are described above. The sealers and cappers do not require spares or routine maintenance and should be kept clean by wiping them with a damp cloth after use.

Pressure cookers

These heat foods to either 110^{o}C or 120^{o}C, depending on the setting of the pressure valve. Foods are place in the pan and the lid is securely sealed. The pressure valve is place on the pipe in the lid, following the manufacturer's instructions to set the required position. The pan is heated until steam escapes from the pressure valve and the heat is then reduced to maintain this pressure. If steam emerges from under the lid, immediately remove the pan from the heat and when cool, replace the gasket seal around the lid.

It is dangerous to use a pressure cooker with a faulty seal.
There is the risk of an explosion and personal injury.

The pressure cooker is cleaned with detergent and a brush and rinsed with clean water. A spare gasket should be kept and the gasket should be checked monthly for signs of damage.

Protective gloves, hats, hairnets, coats, boots

Gloves and boots should be washed daily using detergent and rinsed with clean water. Depending on the amount of soiling, coats should be cleaned either daily or weekly at a laundry. Hats and hairnets should be cleaned as required.

Pulper finishers

Two types of pulper-finishers are supplied by UNIDO: one from Treeshade Engineering and one from Raja Industries. The Treeshade pulper produces a coarser pulp but can handle harder fruits. The Raja pulper is more suited to pulping tomatoes and other softer fruits. It is supplied with a coarse and fine mesh screen.

Important: These machines are not fitted with safety devices to stop the motor if they are opened. Ensure that the machines are isolated from the mains electricity supply before dismantling them for cleaning or maintenance

Treeshade pulper

Fig. 5.17 Treeshade pulper

Fig. 5.18. Pulping mechanism

Coarse-chopped fruit or pulp is fed into the hopper and juice emerges from the base of the machine. Skins, seeds etc are discharged down a chute. To clean the pulper the following steps are taken:

1. Remove the cover
2. Unscrew the two large handles and remove the cover of the casing
3. Wash the casing cover with a water spray
4. Wash the pulping bars, screen and all internal parts with the water spray
5. Allow components to dry before re-assembling the pulper

Routine maintenance consists of:

- weekly checks on the belt tension (maximum 2cm sideways movement midway along the belt)
- weekly checks of electrical connections
- monthly oiling of bearings

Raja pulper

The machine is used in the same way as the Treeshade pulper. To clean the pulper after use:

1. Unscrew the two wingnuts on the end of the pulper and remove the chrome plate
2. **Carefully** slide the screen out of the pulper, ensuring that it is removed horizontally.
3. Wash the screen thoroughly, using a brush and detergent. Rinse with a water spray and allow to dry.
4. Wash the hopper with detergent. Rinse with clean water and allow to dry.
5. Wash the screw, casing and screen thoroughly, using a brush and detergent. Rinse with a water spray.
6. Clean the chute and juice/pulp pipe with a water hosepipe and spray gun.
7. Ensure that no particles of fruit remain in the machine after cleaning.

Fig. 5.19 Raja pulper

Routine maintenance consists of:

- weekly checks on the belt tension (maximum 2cm sideways movement midway along the belt)
- weekly checks of electrical connections
- monthly greasing of bearings

Note: a spare drive belt and fuse should be kept for either pulper.

Reamers

There are two types of reamer that are used in fruit processing: one is designed to extract coconut meat from the shell and the other is used to extract juice from halved citrus fruits. A citrus juice reamer attachment can also be obtained to fit an electric mixer. Both reamers do not require spare parts or routine maintenance. Clean using detergent and rinse with clean water.

Fig. 5.20. Citrus reamer

Refractometers

A refractometer measures sugar concentration as ^{o}Brix, which corresponds to % sugar. There are two ranges: 0-50^{o} Brix for juices, sauces, syrups etc. and 40-80^{o} Brix for jams and other concentrated preserves. Some manufacturers also now supply a single range instrument (0-80^{o} or 0-90^{o} Brix).

Fig. 5.21. Refractometer

They are expensive instruments but they give an accurate measurement of sugar concentration. There are no spare parts or maintenance required. To clean the refractometer after use, wipe the glass with tissue paper or a soft cloth and rinse it with distilled water.

Scales

Small scales (0-2kg) have been supplied by UNIDO to weigh out small amounts of ingredients or laboratory chemicals and larger scales (0-50kg) for weighing fruit and vegetables. **Care is needed to properly clean scales if they have been used to weigh chemicals.** The small scales can be operated using batteries or mains power. The large scales should be hung fro a door lintel. Calibrated scoops, cups or other measures, which contain the correct quantity of an ingredient when filled level with the top, can also be used instead of scales. Operators should be trained to ensure that they use them properly to measure consistent weights. The scales have no spare parts or routine maintenance. They should be cleaned after use using a damp cloth.

Sulphuring cabinet

A cabinet can be made from wood, covered in either plywood or polythene and fitted with mesh trays to hold the fruit. The cabinet can be either lifted off the stack of trays for loading/unloading fruit or it can be fitted with a sealable door. The aim is to retain sulphur dioxide gas from burning sulphur inside the cabinet so that it can penetrate the fruit. There are no spare parts or routine maintenance. Trays are cleaned after use with a brush and detergent, rinsed with clean water and properly dried in the sun before reuse.

Checklist 5

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer

Question	Tick	Notes
1. Do you know where to obtain the equipment needed for your production?		
• Airlocks		
• Blanchers		
• Boiling pans/ pasteurisers		
• Bottle coolers		
• Bottle washers		
• Bottlebrushes		
• Corers		
• Corkers		
• Crown cappers		
• Cutting boards		
• Deep fat fryers		
• Dicers		
• Dryers		
• Energy saving charcoal stove		
• Fermentation tanks		
• Fillers		
• Filters (wine, juice)		
• Food grade drums		
• Freezer		
• Fruit crushers		
• Fruit presses		
• Gas burners • Gas cylinder		
• General tools, work tables		
• Heat sealers		
• Hosepipe and spray gun		
• Hydrometers – alcohol and brine		

• Insect proof door		
• Insulated filling tank		
• Jam thermometer		
• Labellers		
• Laboratory glassware/equipment		
• Liquidisers		
• Motor • Motor isolator • Motor starter		
• Packing table		
• Pasteurising kettle		
• Peelers		
• pH meters		
• Pot sealers		
• Preparation table		
• Pressure cooker		
• Protective gloves, hats, hairnets, coats, boots		
• Pulper finishers		
• Reamers		
• Refractometers		
• Scales		
• Sulphuring cabinet		
2. Do you know how to clean the above equipment?		
3. Do you know how to maintain the above equipment?		
4. Do you know where to get spare parts for the above equipment?		

6 Quality Assurance

All fruit and vegetable products should have a marketable quality and also be safe for consumers to eat. Even at the smallest scale of production, the processor should develop a Quality Assurance (QA) system to ensure this. The following steps are needed to develop a system:

1. Look at every stage of the process, from raw material selection to distribution of products and identify the factors that could affect either product quality or safety
2. Develop procedures to monitor and control these factors so that they do not cause a problem

The basis of QA is to prevent problems from arising, rather than trying to cure them afterwards. Factors that should be examined include the ingredients, particularly any spices that might be contaminated with micro-organisms, the acidity or moisture content of the product and the amounts of any preservatives that are used. Additionally, any sources of contamination from buildings or water supplies should be included (Section 2). The stages in a process where an error could affect the safety of a product are known as Critical Control Points (CCPs) and these are the stages that should be given most attention.

It is important to train all staff to operate the QA procedures that are devised. They should know the limits that are put on any variation from the specified processing method and everyone should understand his or her responsibilities for ensuring that high quality products are made. The more staff that examines the raw materials, ingredients, process and product; the greater the level of control. It is also important to develop reporting procedures and keep records. There should be a plan of what must be done if the process limits are exceeded. Workers should know who has the authority to make decisions and who is responsible for checking that the correct action is taken.

Worked example 7: establishing a QA system

In juice production, the stages in the process (from Table 4.4) and factors to consider are shown as follows:

Inspect	Are all leaves, stalks, mouldy, rotten, damaged or unripe fruits removed?
Wash	Are all surface contaminants (soil, pesticides etc) removed?
Sort/grade	Does the fruit meet processing standards in terms of quality and have all possible contaminants been eliminated?
Extract juice	Do any pieces of fruit remain after pulping? Does the juice have the correct colour?
Fill & seal	Is the container clean and undamaged? Is the fill-weight correct? Does the cap fit properly?
Pasteurise	Are the time and temperature of heating correct?
Cool	Is the product cooled quickly enough to prevent darkening of its colour?
Label	Is the label correct for the product? Is it glued in the correct place?
Store	Are the storage conditions cool and dry?

Table 6.1. Basic list of Critical Control Points identified by the QA system

Process	Monitoring by workers	Control point
Inspect	Remove mouldy, rotten, badly damaged raw materials and all foreign material, e.g., leaves, stems, stalks, sticks, and stones.	CCP – Mouldy, rotten, badly damaged raw materials and foreign matter can contaminate finished product. Sticks and stones can also damage expensive processing equipment.
Wash	Check that fruits are clean	CCP – Water must be potable and clean. Do not use dirty water that could contaminate product.
Sort/grade	Check than no inedible parts are pulped	CCP - A limit of zero stalks, insects, mouldy or unripe fruits (moulds could affect flavour and shelf life of product, extraneous matter could contaminate product)
Extract juice	Inspect juice, check for colour and any pieces of fruit on sieve/cloth. Colour compared to standard colour chart for the product	All juice passes through filter cloth. Juice having poor colour or insufficient sweetness either rejected or blended with other juices
Fill & seal	Check each bottle for cracks and cleanliness. Take a sample of bottles (e.g. every 50th bottle) and check fill-weight. Check cap is sealed properly	CCP - Reject any damaged or dirty bottles. The weight of juice in each bottle is higher than that declared on label. Poorly sealed caps are replaced (faults in glass could injure consumers, faulty seal could allow re-contamination)
Pasteurise	Use a thermometer to check temperature of heating water and a clock/watch to check time of heating	CCP - 90-95^{o}C for 20 mins +/- 1 min (inadequate pasteurisation results in spoilage during storage)
Cool	Check colour of product and whether it is cooled to room temperature within 45 mins	Use fan or bottle cooler to ensure rapid cooling
Label	Check that label is correct for product and properly aligned on bottle	Replace misaligned or incorrect labels
Store	Check storeroom conditions	Modify storeroom if too hot or damp

Once the factors that affect the quality and safety of the product are identified, steps can be taken to monitor and control them as outlined on pages 83 to 88.

Raw materials

Most fruits and vegetables must be harvested when they are fully mature to give the best flavour and colour in products, but many are soft and therefore easily damaged. This allows moulds and yeasts to grow on fruits or rotting bacteria to grow on vegetables. Damage to a few fruits or vegetables can quickly lead to infection of others and the loss of a whole batch. They should be harvested carefully and the following actions taken:

- handlers should be asked to cut their fingernails to prevent them puncturing fruits
- fruits and vegetables should be cooled after harvest and stored in a cool place or covered with wet sacks
- any damaged pieces should be removed to prevent spoilage of surrounding foods
- fruits and vegetables should be filled into crates that are small enough to be carried and not dragged along the ground. Ideally, stackable crates that prevent crushing should be used.

The first inspection of raw materials at the processing unit should include checks on:

- maturity (over-ripe or under-ripe)
- colour
- size or shape (for some products)
- visible mould or rots
- serious bruising or cuts
- presence of large amounts of soil, leaves or other materials.

Remove mouldy, rotten, and badly damaged raw materials along with all visible foreign material (physical contaminants), e.g., leaves, stems, stalks, sticks, stones and rocks. Fruits and vegetables are washed in clean, potable water. Process staff should be trained to remove any mouldy, rotten or badly damaged pieces before washing because these can quickly contaminate the wash-water and infect good quality raw materials. Careful inspection by trained staff is important for saving time and money later in the process. Poor quality raw materials produce poor quality final products because it is not possible to improve their quality by processing them.

Sorting out substandard materials before money is spent processing them is one of the most cost effective methods of ensuring a uniformly high quality and safety in the final product

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Thorough washing will remove surface contaminants, e.g., agricultural chemicals, insects, hair, soil and dirt. It is important that the process staff replace the wash-water when it becomes dirty. Contaminants in dirty water can quickly infect good quality raw materials.

Processing, packaging and storage

Value is added to raw materials at each stage of processing and by the time a product is packaged it has gained most of its final value. Any losses at this stage are therefore the most serious, causing the greatest financial loss to the processor. The QA system should ensure that products are stored in a suitable way to prevent damage or losses.

Products should be stored off the floor in a cool, dark storeroom that has good ventilation and protection against insects and rodents. QA systems should also monitor the time that they remain in storage. Records should show which materials are transferred into and out of the storeroom and when they are used or sold. A First In/First Out (FIFO) system of stock control should be used. It should apply to raw materials, other ingredients and finished products. Processors should also monitor and control distribution to retailers and storage/display in retail outlets.

Testing ingredients and products

The methods for process control described below are each relatively simple and have sufficient accuracy for routine use. Most do not need sophisticated or expensive equipment or high levels of skill. However, many are comparative methods and the results can only be compared with other results obtained by the same method. This is acceptable for routine process control, provided that careful attention is paid to ensuring that exactly the same method is followed each time.

Acidity

In some processes it is necessary to check the pH of a product or the amount of acid that is present. pH is a measure of acidity (pH 1-6), through neutrality (pH 7) to alkalinity (pH 8-14). It can be measured by dipping a piece of pH paper into a sample of liquid food and comparing the colour change with a chart supplied with the paper. For greater accuracy a hand-held pH meter can be used.

pH does not measure the amount of acid in a food. This is important in pickling and sauce making to calculate the Preservation Index. To measure the amount of acid in a product, a 10g sample is mixed with 90 ml of distilled water and 0.3 ml of phenolphthalein indicator solution in a glass flask. The instructions for making the indicator solution are given on the phenolphthalein package.

A solution of 0.1M sodium hydroxide is made by dissolving the weight indicated on the package in distilled water. This solution is filled into a burette and slowly dripped into the flask until a pink colour is formed which does not fade when the contents are swirled around in the flask. The amount of acid in the food is calculated using the formula:

% acid = (number of ml of sodium hydroxide read from the burette) x
(one of the conversion factors below)

It is necessary to know type of acid in the food before selecting the conversion factor.

Acetic acid (vinegar in pickles)	= 0.060
Citric acid (in most fruits)	= 0.070
Tartaric acid (in grapes)	= 0.075

Moisture content

The moisture content of dried fruits and vegetables can be found using a laboratory drying oven. Finely chopped samples are carefully dried in a laboratory oven at 100^{o}C +/- 1^{o}C for 4 hours and reweighed. They are put back into the oven and checked again at hourly intervals until they do not lose any more weight. The moisture content is calculated using the formula:

$$\% \text{ moisture} = \frac{\text{Initial weight of sample - Final weight of sample}}{\text{Initial weight of sample}} \times 100$$

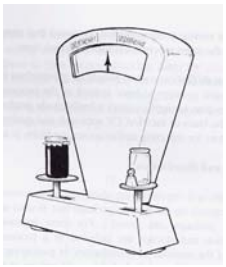
Total solids content = 100- % moisture.
For storage trials, samples of dried product are packed and checked for spoilage each day after storage for 3-4 weeks. Those that have not gone mouldy are checked to find the moisture content. This is the maximum that should be permitted for future products.

Packaging

Bottles and jars are checked more than other types of packaging because of the risk of glass splinters getting into a product, which would seriously harm consumers. All glass containers should be checked for glass splinters, cracks, bubbles in the glass, or strings of glass across the interior. Staff who check bottles or jars should be fully trained to recognise these faults and they should only inspect them for 30-40 minutes at a time to maintain their concentration. If jars or bottles are re-used, they should be checked for residues by smelling them. It is also necessary to periodically check the weights of a number of empty jars or bottles to find the heaviest. This is then used to calculate the checkweight for that product (the weight of the heaviest container plus the weight of product).

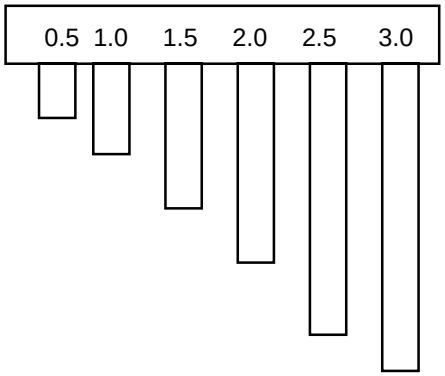
The fill-weight should be the same as the net weight described on the label and random sample of bottles or jars should be checked to ensure the correct net weight using a checkweighing scale. The label should be checked to make sure it matches the actual product in a pack and any sell-by date or batch code numbers on the pack are correct.

A simple gauge can be made to check that the product has been filled to the correct level. See Figure 6.2. on the following page. It is placed on the rim of the container and the level where the product touches one of the prongs is read off. Glass containers are also checked if there is a problem with poorly fitting caps. The diameter at the neck is measured using *go/no-go rings* that show whether the neck diameter is too large or too small for the lid, or whether the neck is circular or oval.



Typical faults with plastic bags and films include incorrect printing, smell of solvents used in their manufacture, layers of film sticking together on a roll, poor seal strength, curling rather than laying flat and incorrect thickness. The last can be measured by cutting 10 squares of film, each 10 cm by 10 cm and carefully weighing them. The result (in grams/square metre) is then checked against the suppliers' specification.

Figure 6.2. Headspace gauge



Pectin content of fruit juices (for jam production)

Pectin is present in all fruits and vegetables, although some contain much more than others (Table 6.2). Pectin is required to make jam or marmalade set as a gel, but it causes a problem in winemaking, where it causes a cloudy haze in the wine that is difficult to remove and lowers the value of the wine.

There are three simple tests that with experience can be used to check the natural pectin content of juice or pulp to determine whether additional pectin should be added for jam-making, or whether a pectic enzyme should be used to make clear wine:

1. Mix an equal amount of juice and methanol (wood alcohol) (**NB this is poisonous - do not taste it!**). Observe the amount and type of material that is precipitated. Juices that are rich in pectin form large amounts of bulky gelatinous material, those that have moderate pectin levels form small clots and those that have little pectin form small flaky pieces of sediment.
2. Mix equal parts of juice and sugar and half the amount of Epsom salts (i.e. a ratio of 1:1:0.5) and leave for 20 mins. If a semi-solid gel forms, there is sufficient pectin for jam making.
3. Add 3 teaspoonfuls of methylated spirit to one teaspoonful of wine in a small jar. Stir it and leave for 30 mins. Any white strings or blobs indicate that the wine contains pectin and should be cleared with a pectic enzyme.

Pectic enzyme powders can be imported. They break down pectin and so remove the haze in wine. If it is known that a juice contains large amounts of pectin, the enzyme powder is sprinkled onto juice before fermentation. However, it is an expensive treatment and processors may wish to see whether haze is a problem before using the enzyme. In this case the enzyme is added when the fermentation has finished and the wine is left to clear. The enzyme may take from a few days to a few weeks to fully clear the wine, depending on the type of fruit that is used.

Table 6.2. Pectin content of different fruits

Apples
Pears
Apricots
Oranges, lemons, grapefruits (without pith in the juice)
Plums
Pineapples
Peaches
Mangoes
Pawpaws
Dates
Figs
Red berries
Vegetables
Grapes
Strawberries
Melons

(highest pectin content at the top, lowest at the bottom)

Salt

The salt concentration in pickling brines can be measured using a special salt hydrometer, calibrated in specific gravity units and converted to % salt using a conversion table.

Sugar (for wine and jam making)

A hand-held refractometer can be used to check sugar concentration in jams, syrups or juices. A small sample is placed on the glass, the lid is closed and the refractometer is pointed towards a bright light. The % sugar is read from where the dark edge passes through the scale.

The final boiling temperature of jams and other preserves can be used to assess the sugar content, using a 'jam thermometer' that reads up to 120°C. The sugar content is 68-72% when the temperature reaches 104-105^{o}C. However, the temperature is affected by the amount of invert sugar in the mixture and staff should have experience of making the product before using temperature alone to control the process. The boiling point also changes with height above sea level and because Uganda has an elevation of 1500-3000 metres above sea level, producers should first check the boiling point of water and make the necessary corrections. With experience, staff can also estimate the solids content of preserves by cooling a sample of the boiling mixture and noting the texture to see if a firm gel forms.

The concentration of sugar in juices and syrups can also be assessed by measuring their specific gravity (SG), using a hydrometer. Juices should be tested at 20^{o}C +/- 5^{o}C, which is the reference temperature for the hydrometer. The specific gravity reading is converted to sugar concentration using Table 6.3. The reading can also be used to estimate the alcohol concentration of the wine after it has been fermented (See sample calculations)

Table 6.3. Specific gravity readings, sugar content and potential alcohol content

Specific gravity	Sugar (g/litre)	Potential alcohol (%)	Specific gravity	Sugar (g/litre)	Potential alcohol (%)
1.000	0	0	1.080	209	10.3
1.005	13	0.6	1.085	222	11.0
1.010	26	1.3	1.090	235	11.6
1.015	39	1.9	1.095	248	12.3
1.020	52	2.6	1.100	261	12.9
1.025	64	3.2	1.105	275	13.5
1.030	78	3.9	1.110	288	14.2
1.035	91	4.5	1.115	301	14.8
1.040	104	5.2	1.120	314	15.5
1.045	117	5.8	1.125	328	16.1
1.050	130	6.4	1.130	341	16.8
1.055	143	7.1	1.135	355	17.4
1.060	157	7.7	1.140	368	18.1
1.065	169	8.4	1.145	381	18.7
1.070	183	9.0	1.150	394	19.3
1.075	195	9.7			

Worked example: 8 Using a hydrometer

1 Estimating alcohol content
Before fermentation, the SG of juice is measured at 1.070. Using Table 6.2, if the fermentation takes place normally, the expected alcohol content of the wine will be 9.0%.

2 Calculating how much sugar to add to juice
You wish to make a wine that has 11.0% alcohol. The SG of juice is measured at 1.020, which shows that it contains 52 g per litre of sugar. However, to make a wine that has 11% alcohol the juice should contain 222 g/l. It is therefore necessary to add the difference – i.e.: 222 – 52 = 170 g/l

3 Calculating the actual alcohol content of wine
Table 6.2 can be used to estimate potential alcohol content, but a more accurate method of calculating the actual alcohol content in wine is to measure the initial SG of juice, then the final SG after fermentation and multiply the difference by a factor of 129.
E.g. Pineapple juice has an SG of 1.080 and the wine has an SG of 0.990 after fermentation.
The drop in SG = (1.080 – 0.990) = 0.090.
Multiplying by 129, the alcohol content = 0.090 x 129 = 11.6%

Checklist 6

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer

Question	Tick	Notes
1. Do you have a QA programme for your products?		
2. Do you have schedules for routine inspection and cleaning of the processing unit?		
3. Does your processing room meet legal requirements for hygiene and sanitation?		
4. Do you know how to test your products?		
5. Do you know how to check your packaging?		
6. Do your products meet legal requirements for fill-weight and label design and information?		

7 Summary of Legislation and Regulation

International

Global efforts to establish and improve consumer health protection have led to increased governmental and regulatory oversight in the field of food safety. While most people presume the foods they eat are safe, several recent food safety events have eroded this confidence and led to demands from the public for additional protective measures to be enacted to establish the rights of consumers to safe food. The scope of this protection has expanded beyond the practices of the food manufacturers and now extends all the way back to the farm gate. It is essential that safety be embodied in food products from production through consumption, from the farm to the table (food chain approach). All stakeholders in the food chain, including the supply side (producers, transporters, processors, and merchants), the government inspection and regulatory authorities, the support institutions (labs, R&D and training centres), and consumers will now have responsibilities and obligations to ensure the safety of food products and protect consumer health.

For enforcement purposes, the Codex Commission has developed several guidelines and food standards. There are today approximately 250 standards and specific requirements for individual foods, groups of foods, and other provisions, e.g., hygiene, contaminants, labelling, and food additives.

Enforcement of food control has evolved from the traditional focus on inspection of final products and removal of unsafe food from the market to the current holistic and preventive approach, which relies more on system control. In addition to the traditional GMP (or GHP), formalized control operations relying on hazard analysis and risk prevention have been made mandatory in the main markets. This systematic approach to the identification, assessment, and control of hazards is known as the Hazard Analysis and Critical Control Point (HACCP) system.

The introduction of a HACCP-based food safety system may be difficult for small-scale enterprises and will be best achieved by coordination between the food industry, educational and training organisations, and governing authorities. There are various guides and training information on the introduction and application of HACCP in the food chain.

Uganda

At the time of the preparation of this manual in 2004, the Government of Uganda was in the process of developing the National Food Safety Strategic Plan. The Parliament was also debating a draft Food Safety Bill. Once enacted, the “Food Law” or the “Food Safety Law” will contain provisions for the mandatory implementation of GMP and/or HACCP programmes within the food chain. This law was proposed to develop an effective national food safety control system to protect the health and wellbeing of consumers, as well as, meeting international standards and requirements for the trade of food products.

There are various laws governing the setting up, registration and operation of a food processing enterprise In Uganda. Failure to follow the law may lead to punishment by the authorities or closure of the business. Processors should check the local laws with the UNBS.

In summary the registration of a mill or bakery involves the following:

- Registration of the enterprise with the Ministry of Trade and Industry
- Obtaining a Certificate of Share Capital (for limited companies), or a Certificate of Incorporation (for corporate companies)
- Obtaining an Occupational Certificate from the Local Authority or the Planning Authority in the Land Ministry
- Obtaining a Health Permit or Licence from the Local Authority or Ministry of Health to allow the premises to be used for food production
- Obtaining a Manufacturing Licence, issued by the Local Authority
- Obtaining Medical Certificates from the Health Authority to certify that workers are fit to handle food
- Registration with the Revenue Office.

Hygiene and sanitation

Together, a manager and processing staff should develop a cleaning plan and personal hygiene rules to ensure product safety. If a member of staff reports a stomach illness or skin infection, he/she should be transferred to jobs that do not involve handling the product. There should also be proper cleaning materials and equipment available and adequate time set aside for cleaning machinery and processing areas after production has finished.

All food production facilities must comply with the Code of Practice for Hygiene in the Food and Drink Manufacturing Industry, US 28:2001.

Food composition

There are four types of general laws in Uganda that govern the sale of all goods, including fruit and vegetable products. These state that:

1. The product should be suitable for its intended purpose
2. It is an offence for anyone to add anything to food, to process it or to sell food for human consumption if it harms consumers' health
3. To protect customers from adulteration of foods or other forms of cheating, it is an offence to sell food that is not of the nature, substance or quality demanded by the purchaser
4. It is an offence to falsely describe a food on the label or in advertising, with the intention of misleading the customer.

There are also laws that deal with the safety of foods, the hygiene of operators and sanitation of premises where foods are made. In summary the laws are concerned with the following aspects of health, hygiene and sanitation:

- Processing that is carried out in unsanitary conditions or where food is exposed to the risk of contamination
- Equipment (which must be able to be cleaned and kept clean)
- Persons handling food and their responsibilities to protect it from contamination
- Building design and construction including water supplies, drainage, toilet facilities, wash-hand basins, provision of first aid facilities, places to store clothing, facilities for washing food and equipment, lighting, ventilation, protection against infestation by rats and insects and removal of wastes.

If in doubt, entrepreneurs should seek advice from staff in the Bureau of Standards or from food technologists at Makerere University Dept. of Food science and Technology or UIRI.

The intention of laws relating to the composition of processed fruits and vegetables is to produce a standard for a particular food and so ensure that all foods sold with that name have a similar composition. If export to Europe, ASEAN or USA is being considered, it is necessary to obtain a detailed specification of the product composition and quality from the Export Development Board, from importing companies or their agents, or from the Trade Section in Embassies of the countries concerned. It should be noted that many countries now have mandatory GMP and HACCP standards that apply to exporters, as well as, domestic producers. The European Union, in particular, has recently enacted very stringent food safety regulations and directives. Be sure to check on specific details before attempting to export. In relation to the composition of fruit and vegetable products, the following standards are in force in Uganda:

Fruit juices and nectars

Juices should be only pure juice with nothing added except vitamin C (ascorbic acid), specified acids used to adjust the hand maximum levels of residual sulphur dioxide if this has been used as a preservative. **Nectars** should contain a minimum % juice, between 25% and 40% juice depending on the type of fruit and a maximum of 20% sugar or honey. There are also minimum limits for the acid content of nectars.

Soft drinks

Squashes, crushes and cordials are each defined in law and have minimum fruit contents specified for different types of fruit. These are between 1.5% and 5% minimum fruit content for drinks that are not diluted and 7% to 25% minimum fruit content for those drinks that require dilution. Dilution must be four parts water to one part drink. They each have maximum permitted levels of sugar or artificial sweeteners and can contain specified food acids.

Jams and similar products

Jams should contain a minimum amount of fruit pulp, which varies with the type of fruit being used, but for many is 200g pulp per kg product. Similarly the amount of fruit juice in jelly and marmalade is specified. The fruit content of marmalade should not be less than 20% citrus fruit. In mixed fruit jams, the first named fruit should be at least 50% of the total fruit content.

Normally jams should have minimum of 60% soluble solids (in practice 68%-70% is used to achieve adequate preservation, especially in the tropical climate of Uganda) and there are limits on residual sulphur dioxide in all products. There are detailed regulations covering definitions of the names *jams, jellies, marmalades, conserves, preserves, extra jam or jelly* and *reduced sugar jam, jelly or marmalade*. The Uganda Standard Specification for Jam (fruit preserves) and Jellies is US 31:1999 and the Standard for Citrus Marmalade is US 32:1999.

Tomato ketchup

This should have a minimum of 6% tomato solids and not contain seeds. There is a maximum limit on contamination with copper and no other fruits or vegetables can be used except onions, garlic or spices for flavouring. The Ugandan Standard for Tomato Ketchup is US 38:1999 and the Standard for Tomato Sauce is US 39:1999.

Additives and contaminants

There are lists of permitted food colours, emulsifies, stabilisers, preservatives and other additives that can be added to foods. Any chemical that is not on these lists cannot be used. There are also maximum levels set for each additive in specific foods and lists of foods that are able to contain specified preservatives. Contaminants, including poisonous metals such as arsenic and lead, have maximum permitted levels in specified foods.

Food labelling

It is in the processors' interest to involve the Bureau of Standards at an early stage of label design to avoid errors, which would result in an expensive re-design after labels have been printed. The UNBS has a 'General Standard for labelling of pre-packed foods' (US 7:2002) that describes the information that must be included on a label, but there are also detailed laws concerning the following aspects:

- Specific names that must be given to different types of ingredients
- Ingredients that are exempt from the law
- The use of words such as *best before* and *sell by*
- The declaration of alcohol content on spirit drinks
- Locations of the name of the food, the sell-by date and the net weight (they must all be in the same field of vision when a customer looks at the label)
- The visibility of information and the ability of customers to understand it (including the relative print sizes of different information)
- Claims and misleading descriptions, especially about health-giving or tonic properties, nutritional advantages, diabetic or other medicinal claims
- Specifications of the way in which certain words such as *flavour*, *fresh*, *vitamin* etc. can be used.

This is a complex area, which is not possible to describe in detail in this book and professional advice should be sought from graphic designers who are experienced in label design, or from the Bureau of Standards. The legal requirements are that a label should contain the following information in Uganda:

- Name and address of the producer
- Name of the product
- List of ingredients (in descending order of weight)
- Net weight of product in the package
- A 'use-by' or 'sell-by' date.

In addition, a processor may include:

- Instructions for preparing the product
- Storage information or instructions on storage after opening
- Examples of recipes in which the product can be used
- An 'e-mark' if export to Europe is contemplated
- A bar code.

The laws are to ensure that the amount of food that is declared on the label as the net weight (the weight of product in a pack) is the same as the weight of food that is actually in the pack. The weights and measures legislation in force in Uganda is known as the *Minimum Weight System*. This ensures that every pack of food contains at least the net weight that is written on the label. If any pack is found below this weight the producer is liable for prosecution. (Another type of legislation in Europe is known as the *Average Weight System* and is based on a proportion of packages being above the declared weight. If a processor is considering export to Europe, advice and information on this legislation should be obtained from the Export Development Board and the National Enquiry Point at UNBS, so that an *'e' mark* can be obtained to indicate that the process conforms to this system). There are also specified weights that must be used when selling dried fruits and vegetables and jams or marmalades (but not other processed fruit and vegetable products).

Water

Only potable water may be used in food operations. Potable water is drinking water that is wholesome and clean and does not cause illness. It is free from any micro-organisms and parasites and from any substances that in numbers and concentrations, constitute a potential danger to human health. It should meet standard US 201:1994 as established by UNBS.

Summary

To achieve optimum consumer protection, it is essential that safety be incorporated in food products from production through consumption. All participants in the food chain from the primary producer to the processor to the vendor to the consumer play vital roles in ensuring food safety. Each has different responsibilities, but all must work together in an integrated farm-to-table approach.

Checklist 7

Can you answer these questions? Tick the box if you know the answer. Write notes on what you currently do or need to do to find the answer

Question	Tick	Notes
1. Do your products meet legal requirements and US standards for product specification?		
2. Do your products meet legal requirements for fill-weight and label design and information?		
3. Do you know the basic requirements of the new Food Safety Law and how it impacts your business?		

Annex A
Sources of further information and assistance

The following organisations may be able to help solve specific problems, offer advice or information:

- Action Aid, 2514 Gaba Rd, Kampala, T: 266640
- ADC (Agribusiness Development Centre), PO Box 7856, 18 Prince Charles Drive, Kololo Kampala, T: 255482/83/68, F: 250360, E-mail: adc@starcom.co.ug
- AEATRI (Agricultural Engineering and Appropriate Technology Research Institute), PO Box 7144, Kampala, Email: aeatri@starcom.co.ug
- Aga Khan Foundation, 4 Parliament Ave, Kampala, T: 256165/ 255884
- ATI (Appropriate Technology International), 22a Namirembe Rd, Kampala, T: 349147
- Austrian Development Corporation, 6 Entebbe Rd, Kampala, T: 233002
- DIFD (Department for International Development - UK Govt), PO Box 7070, Rwenzori Building, Kampala, T: 348731/33, F: 348732, E-mail: info@dfid.gov.uk
- Department of Industrial Art and Design, Makerere University, PO Box 7062, Makerere Kampala, T: 531423, E-mail: fineart@imul.com
- DFST (Department of Food Science and Technology), Makerere University, PO Box 7062, Kampala, T/F: 533676, E-mail: foodtech@infocom.co.ug
- Department of Food Science, Uganda Polytechnic Kyambogo, PO Box 26486, Kampala, T: 285211
- Department of Home Economics, ITEK (Institute of Teacher Education, Kyambogo), PO Box 1 Kyambogo, Kampala, T: 285001/2, F: 220464, E-mail: itek@starcom.co.ug
- European Development Fund - Microprojects Programme, 24b Lumumba Ave, Kampala, T: 230033/ 35, 254613, 232487
- FAO (Food and Agriculture Organisation), 72 Buganda Rd, Kampala
- FIT Programme, P. O. Box 24060, Kampala, T: 221785, F: 221038, Email: fituga@imul.com
- FOSRI (Food Science and Technology Research Institute, part of NARO), PO Box 7852, Plot M217, Nakawa Industrial Area, Jinja Rd, Kampala, T: 222657/285248/077 594980, F: 222657, E-mail: fosri@imul.com
- Gatsby Trust, Faculty of Technology, Makerere University, PO Box 7062, T: 531048/545029, 077 408762, F: 542377, e-mail: gatsby@techmuk.ac.ug
- German Development Services, 1773 Muyenga, Tank Hill, Kampala, T: 268662/0
- KARI (Kawanda Agricultural Research Institute), PO Box 7065, Kampala, E-mail: karidir@starcom.co.ug
- IITA (International Institute for Tropical Agriculture), Marketing & Post Harvest Research East & Central Africa, PO Box 7878, Bandali Rise, Bugolobi, Kampala, T: 220217/077 472103, F: 23460, 223459, E-mail: foodnet@imul.com
- MAAIF (Ministry of Agriculture, Animal Industries and Forestry), PO Box 102, Berkeley Lane, Entebbe, T: 20980/3/8
- Midway Centre, c/o MTAC (Management Training & Advisory Centre), PO BOX 24050 Jinja Road, Nakawa, Kampala, T/F: 223505, E-mail: midway@imul.com
- Ministry of Health, PO Box 8, Kitante Rd, Kampala. T: 20209/0, F: 20474
- MUBS (Makerere University Business School, Business Development Centre), PO Box 1337, New Port Bell Rd, Kampala, T: 223859, F: 221682, Email: commerce@starcom.co.ug, commerce@infocom.co.ug
- NAARI (Agriculture and Animal Production Research Institute), PO Box 7084, Namulonge, E-mail: naari@naro.bushnet.net
- NARO (National Agricultural Research Organisation, Kawanda), Post Harvest Research Programme, Kawanda Agricultural Research Institute, PO Box 7065, Kampala, T: 567708, F: 567649, E-mail: karihave@starcom.co.ug
- NARO (National Agricultural Research Organisation) and FOSRI (Food Science Research Institute), PO Box 7852, Kampala, F: 222657, Email: fosri@imul.com
- Nile Vocational Institute, PO Box 1829, Njeru, Jinja, T: 22389/22019

- PRESTO, PO Box 24204, Plot 21 Kawalya Kaggwa Close, Kololo, Kampala, T: 347481-3, F: 347635, E-mail: presto@imul.com
- PSF (Private Sector Foundation), 3 Kintu Rd. Kampala, T: 342163, F: 230956
- Redd Barna, 42 Bwala Hill, Masaka or 4105 Libuba Katwe, T: 21015, 268675
- Sasakawa Global 2000, Ruth Towers, PO BOX 6987, Kampala, T: 345497, F: 346087, E-mail: sguganda@starcom.co.ug
- SCF (Save the Children Fund), 5 Baskerville Ave, Kololo, Kampala, T 344796, 258815, 343486
- Small Enterprise Development Company41 Oboja Rd, Jinja and 20 Kazooba Rd, Kabale, T: 21997
- SNV (Netherlands Development Organisation), PO Box 8339, 36 Luthusi Rise, Bugolobi, Kampala, T: 220584/2, 220780
- Ssemwanga Centre For Agriculture & Food, 47b Upper Kololo Terrace, Kampala, PO Box 40257, T: 346246/075 694612, F: 346246, E-mail: ssemwang@swiftuganda.com
- UMA (Uganda Manufacturers Association), PO Box 6966, Lugogo Showgrounds, Kampala, T: 220285/ 221034, F: 242455
- UIRI (Uganda Industrial Research Institute), Nakawa Industrial Estate, Plot M217 Jinja Rd, Kampala, PO Box 7103, T: 286245/077 406502, F: 285689,
- UNBS (Uganda National Bureau of Standards), PO Box 6329, Plot M217, Nakawa Industrial Area, Kampala, T: 222367/9, F: 286123, E-mail: unbs@starcom.co.ug
- USSIA (Uganda Small Scale Industries Association), PO Box 7725, Lugogo Showground, Kampala, T: 221785, F: 221038, E-mail: ussia@starcom.co.ug. Also PO Box 2344, Mbale
- VTI (Vocational Training Institute), PO Box 20121, Nakawa, Kampala, T: 20935/220028/236864

Workshops

- Mr Kigongo-Kawesi, Tree Shade Technology Services, Bombo Road, Kampala, P O. Box 5833, T: 567698, F: 567698
- Mr Baljit Singh, JBT Engineering, Old Kampala, PO Box 11991, Kampala, T: 531339/077 488137
- Mr Bernard Bosso, Mechanical Engineering Department, Uganda Polytechnic Kyambogo, Kampala
- Mr Douglas Serroul, Adtranz, (Uganda Railways Mechanical Workshop), Nalukolongo, Masaka Rd, Kampala, T: 200580, F: 256047, E-mail: adtranz@infocom.co.ug
- Mr Fred Mukasa, Steelex, Bombo Road, PO Box 1765, Kampala, T: 567950

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- *Processing Tropical Crops*, Asiedu, J.J., 1989, MacMillan Press Ltd, London, (ISBN 0-333-44857-X)
- *Small Scale Food Processing: a guide to appropriate equipment*, Fellows, P. and Hampton, A., 1992, IT Publications, 103-105 Southampton Row, London WC1B 4HH, UK (ISBN 1-85339-108-5)
- *Starting a Small Food Processing Enterprise*, Fellows, P., Franco, E. and Rios, W., 1996, IT Publications, London, UK. (ISBN 1 85339 323 1).
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Quality Assurance

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- *How to HACCP, an illustrated guide*, Dillon, M and Griffith, C.,1999, MD Associates, 34a Hainton Avenue, Grimsby, UK.
- *Quality Assurance for Small Scale Rural Food Industries,* Fellows, P.J., Axtell, B and Dillon, M., 1995., FAO Agricultural Services Bulletin # 117, FAO Publications, Via delle Terme di Caracalla, 00100 Rome, Italy. (ISBN 92 5 103654 3)

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Sanitation and Hygiene

- *Affordable Water Supply and Sanitation*, Pickford, J., Barker, P., Coad, A., Dijkstra, T., Elson, B., Ince, M. and Shaw, R (Editors), 1995, IT Publications, London, UK. (ISBN 1 85339 294 4).
- *Codes of hygienic practice of the Codex Alimentarius Commission*, Anon, Joint FAO/WHO Food Standards Programme, FAO Publications, Via delle Terme di Caracalla, 00100 Rome, Italy.:
- *Disinfection of Rural and Small-Community Water Supplies*, Anon, 1989, Water Research Centre, Medmenham, Bucks, UK.
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- *The Food Hygiene Handbook*, Sprenger, R.A., 1996, Highfield Publications, Doncaster, DN5 7LY, UK (ISBN 1 871912 75X).

Packaging Materials and Labelling

- *Appropriate Food Packaging*, Fellows, P. and Axtell, B., 1993, IT Publications, London (ISBN 90 70857 28 6).
- *Packaging*, Obi-Boatang, P. and Axtell, B.L., 1995, Food Cycle Technology Sourcebook: IT Publications, London, UK.

Training

- *Successful Approaches to Training in Food Processing,* Battcock, M. Azam-Ali, S. Axtell B. and Fellows P.J., IT Publications, 136pp, 1998

Websites related to quality assurance, food safety, GHP, GMP and HACCP:

- Codex Alimentarius Commission, Official Standards, http://www.codexalimentarius.net/search/search.do
- EurepGAP, The Global Partnership for Safe and Sustainable Agriculture, http://www.eurep.org
- European Union, the search page to find any EU Regulations (legislation in force), draft Regulations, dates of applicability, http://europe.eu.int/eur-lex/en
- European Union, Food Safety – From the Farm to the Fork – Site Map, http://europa.eu.int/comm/food/site_map_en.htm
- European Union, European Food Safety Authority, http://www.efsa.eu.int/index_en.html
- EU and UK Food Law, University of Reading, http://www.foodlaw.rdg.ac.uk/index.htm
- UK Food Standards Agency, http://www.food.gov.uk
- WHO Guidelines for Drinking Water Quality, http://www.wto.int/water_sanitation_health/dwq/guidelines/en

Annex B
Processes and products that are not described in detail

Canning

Canning is not suitable for small scale processing for the following reasons:

- Cans are not readily available in Uganda and are expensive to import. Different fruit or vegetable products require a particular internal lacquer on the can to prevent the metal corroding and these lacquers are not always available on imported cans. There is a minimum order size when cans are imported from South Africa or Kenya, which is too large for individual processors.
- A 'seamer' is needed to seal the lid onto the can, which is relatively expensive. The seamer needs regular checks and maintenance by an experienced technician to ensure that seams are properly formed. A 'seam micrometer' is required to do this and it is an expensive instrument. Any failure in a seam leads to contamination and risks creating spoiled or dangerous canned foods. Canning therefore requires a high capital investment, trained and experienced staff, a regular supply of the correct types of cans and comparatively high operating costs.
- Canning vegetables are not a suitable process for small-scale operation. In addition to the above points, vegetables have to be heated to 121^{o}C to kill food poisoning bacteria. This is achieved using high-pressure steam from a boiler and a strong vessel named a 'retort'. Additionally, an air compressor and controllers are needed to maintain the pressure while cans are being cooled. This equipment is likely to be too expensive for a small-scale processor.

Papain

Papain is an enzyme found in the skin of papaya and is used for meat tenderising and many other applications. There are no known users of papain in Uganda, although it is produced and exported by Reco Industries. Papain is collected by making shallow cuts in the skin of unripe fruits while they are on the tree. The fruits produce a sticky white ‘latex’, which is collected by scraping the fruit each day for several weeks. This is spread out in shallow trays and sun-dried until it becomes brittle. The latex should be handled with gloves to avoid damage to the skin. The equipment needed to process papain in commercial quantities is relatively large scale and expensive, particularly to achieve the high quality required for export. It is also necessary to plant papaya trees in orchards, rather than collecting it from widely scattered trees to minimise collection costs.

Pectin

It is difficult to make specific grades of pectin or powdered pectin at a small scale, but jam-makers can increase the amount of crude pectin in products such as melon that are naturally low in pectin. Pectin can be extracted from citrus peels such as lime, lemon, orange, from passion fruit or from apple 'pomace' (material left after juice has been extracted). Peels are cut into thin slices (e.g. 1cm wide) and other fruits are coarsely chopped. They are added to approximately 8 times their weight of water and heated gently to simmer for 20-30 minutes. This extracts the pectin and also removes water to concentrate the pectin, so that it can be stored for a few days. However, over-long heating degrades the pectin and it loses some of

its gelling power. The peels are removed and the pectin solution is used as an ingredient in jam making.

Spirits

Distillation involves vaporising the alcohol in wine by heating and then condensing it to concentrate the alcohol as spirit drinks (usually standardised at 40% alcohol). A still is a drum or other vessel, fitted with a safety valve and a pipe to carry away the vapour. Wine is placed inside the drum and heated. The alcohol vapour is passed through cooled air or cool water and the distillate condenses and is collected. As well as alcohol, there is a range of other chemicals in wine, some of which have unpleasant flavours that are also evaporated by heat. There is great skill involved in judging the correct time to start collecting the distillate and when to stop the collection, so that these chemicals are not present in the spirit. Any fruit-based spirit would need to compete with Waragi and cheap, products made in rural areas. The production and sale of spirits is regulated and because of this and the competition from existing products, it is difficult to envisage a situation where a small-scale spirit producer could operate both legally and profitably.

Vinegar

Vinegar can be made by fermenting wine using acetic acid bacteria *(Acetobacter species)* to convert the alcohol to acetic acid (spoiled wine is often due to unwanted acetic acid bacteria). Typically, vinegar contains 6-10% acetic acid, which preserves the product for many months/years provided that it is sealed in an airtight container to prevent the acetic acid from evaporating. Synthetic or ‘spirit’ vinegars are on sale in Uganda, made from concentrated acetic acid that is diluted with water. Fruit vinegars are not made at present in Uganda and the demand is therefore not known. The demand for vinegar is relatively low and it is unlikely that a small-scale producer could sell sufficient to operate profitably or compete against imported spirit and malt vinegars.

Annex C
Glossary and Acronyms

Acid preserves	foods that have a high acid content that inhibits spoilage.
Adulteration	deliberate contamination of foods with materials of low quality.
Brix	units of measurement of sugar concentration
Case hardening	the formation of a dry skin on a wet food due to over-rapid drying. It slows the rate of drying and can lead to spoilage during storage.
Chlorination	the addition of chlorine to water to destroy micro-organisms.
Contamination	materials that are accidentally included with a food (e.g. dirt, leaves, stalks etc.).
Critical control Points	stages in a process where quality control can have a major effect on food quality or safety.
Cross contamination	the transfer of soils or micro-organisms from raw food to processed food
Enzymes	natural proteins in foods that can cause changes to colour, flavour or texture of the food.
FIFO	First in, first out inventory scheme for raw materials and finished products.
Fill-weight	the amount of food placed into a container or package and written on the label (also net weight).
Humidity	the amount of water vapour in air.
Hydrometer	an instrument that measures specific gravity of liquids, used to measure salt, sugar or alcohol concentration.
Low-acid foods	foods that have little acid and therefore can contain food poisoning bacteria if poorly processed.
Micro-organisms	tiny forms of life, invisible until they are in large numbers, including moulds, bacteria and yeasts.
Minimum weight	all packages have a fill-weight equal to or greater than that shown on the label.
Net weight	the amount of food filled into a container.
Pectin	a natural gelling agent found in some fruits
pH	a scale used to express acidity or alkalinity, from 1 (strong acid) through 7 (neutral) to 14 (strong alkali).
Potable water	clean and wholesome water that will not cause illness.
Preservation index	a figure that is calculated to show that the amounts of acid, sugar and salt are enough to prevent spoilage of foods.
Quality assurance	a management system which controls each stage of food production from raw material harvest to final consumption.
Refractometer	an instrument that measures the refractive index of a liquid, which is used to measure soluble solids in syrups or salt in brines.
Shelf life	the time that a processed food can be stored before changes in colour, flavour, texture or the number of micro-organisms makes it unacceptable.
Sodium benzoate	a chemical preservative that is particularly effective against yeasts.
Sodium metabisulphite	a chemical preservative that is effective against moulds and yeasts.

Acronyms

CCP	Critical Control Point
FIFO	First in, First out inventory control system
GHP	Good Hygienic Practices
GMP	Good Manufacturing Practices
HACCP	Hazard Analysis Critical Control Point system
ROPP	Roll on Pilfer Proof (caps for bottles)
TOTO	Twist on Twist off (lids for jars)
UHT	Ultra-High Temperature (sterilisation of foods)