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Good Agricultural Practices
Melongene Production

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PREFACE

Consumers generally expect the food they eat to be safe. Although individuals can take responsibility for the safety of the food they produce themselves, very few people produce all of the food they consume. This means they must rely on farmers, distributors and processors for the safety of much of what they eat. As such it requires that systems are established to facilitate the safe production of food along the entire agri-food chain.

At the farm level, Good Agricultural Practices are the main requirements for the adoption and application of food management practices for the production of fresh fruits and vegetables without affecting the environment and the lives of farm workers.

This document provides a general guide to the production methods that will ensure the delivery of good quality products.

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1.0 INTRODUCTION

1.1 Importance of adopting good agricultural practices

Over the past two to three decades there has been an increase in food borne illnesses associated with the consumption of fresh fruits and vegetables (fresh produce). Most of these outbreaks were associated with microbial contamination. The major microbes that have been implicated include *Salmonella, Escherichia coli* 0157:H7, *Campylobacter Listeria monocytogenes* and the *Norwalk* virus. Protozoan type organisms (*Cryptosporidium* sp.) were also implicated in some outbreaks. Nematodes, (*Strongylus* sp.), have also been a source of food borne illness. Traceback studies subsequently indicated that in most cases, breaches occurred during production and postharvest handling which led to produce contamination and illness. In an attempt to reduce these risks Good Agricultural Practices (GAP) Protocols were developed. In 1991, the United States Department of Agriculture (USDA) introduced the first voluntary guidelines whose primary objective was to reduce the microbial population of fresh produce. A European model referred to as EurepGAP was subsequently introduced. The European model, while placing emphasis on microbial reduction, also places great emphasis on integrated pest management and pesticide usage. When first developed GAP was suggested as voluntary guidelines. With the passage of time these guidelines have started to become more enforceable. In fact, in the U.S., more companies that distribute fresh produce are demanding mandatory third party independent audits of fresh produce growers as a prerequisite for purchasing. In January 2006, the European Union (EU) is set to implement its pesticide initiative programme. This measure will have tremendous implications for Caribbean exporters whose products are marketed in the European Union. In addition, the International Standardization Organisation (ISO) is in the process of finalising an international food safety standard ISO 22000:2005. When finalised by December 2005, GAP and EurepGAP will be made mandatory as the Prerequisite Programme (PRP) for all suppliers, inputs entering food establishments that wish to become certified. The protocols presented in this document combine aspects of both the American model and EurepGAP.

1.2 Principles of GAP

The U.S. model is based on 8 principles which are also applicable to other models that were subsequently developed. They form a useful basis for implementing any GAP initiative.

Principle 1: Prevention of microbial contamination of fresh produce is favoured over reliance on corrective actions once contamination has occurred.

Principle 2: To minimise microbial food hazards in fresh produce, growers, packers, or shippers should use good agricultural and management practices in those areas over which they have control.

Principle 3: Fresh produce can become microbially contaminated at any point along the farm to food chain. The major source of microbial contamination with fresh produce is associated with human and animal faeces.

Principle 4: Whenever water comes into contact with fresh produce the water's quality dictates the potential for contamination. The potential for microbial contamination from water used with fresh fruits and vegetables should be minimised.

Principle 5: The use of animal manure must be closely monitored to minimize microbial contamination.

Principle 6: Worker hygiene and sanitation practices during production, harvesting, sorting, packing and transport play a critical role in minimising the potential for microbial contamination of fresh produce.

Principle 7: All applicable laws that are aimed at reducing microbial contamination of fresh produce should be obeyed.

Principle 8: Accountability at all levels of the agricultural environment is important to a successful safety programme. Qualified personnel and effective monitoring are critical in ensuring all elements of the programme are operating effectively. This helps to effectively implement traceback through distribution channels if things go wrong.

1.3 Components of the GAP Protocols

The GAP Protocols have identified the major points at which contamination can occur on the farm and during postharvest operations. These points are sometimes referred to the major hazard control points. By following the recommendations aimed at reducing contamination at these points one can significantly reduce the risk of produce contamination. The major components of the GAP protocols are:

- Site selection, topography and land preparation
- Fertilizer application of inorganic and more importantly animal manure
- Worker health and hygiene
- Pesticide safety
- Water quality on farm and in the postharvest environment
- Postharvest operations

2.0 IMPORTANCE OF MELONGENE IN TRINIDAD AND TOBAGO

Melongene (*Solanum melongena)* is an important member of the Solanaceous family. It is referred to by other names including egg plant, aubergine and baigan. It is an important crop locally and continues to be an important crop on the regional export market. At one time a good market was available on the Canadian market. Some of that market share was lost because local exporters were not consistent with the grades and standards expected of them by Canadian importers.

3.0 SITE SELECTION, TOPOGRAPHY AND LAND PREPARATION

3.1 Site Selection

The GAP Protocols place great emphasis on thoroughly evaluating the history of the lands that are intended for production. Land history allows one to ascertain the possibility of risks to human health if these lands were to be cultivated. A number of pertinent questions should be asked and correctly answered before lands are used in the production of fruits and vegetables. It must first be ascertained whether the land was used:

- as a landfill or as a storage for toxic waste
- as a burial ground for either humans or animals
- to dispose of sanitary waste
- as pasture
- for mining or for extraction of oil and/or gas
- for the disposal of incineration material
- for industrial waste or mineral residues

Other considerations include whether:

- the land adjacent to the intended production site was used for animal husbandry
- there has been any flooding on the said land
- the land been used as a site for manure storage

Lands which were used for storing toxic wastes or as landfills pose enormous risks to human health if they are used for crop production. Landfills and toxic waste disposal sites are known to have high concentrations of heavy metals and other toxins. High levels of mercury, lead, cadmium and other toxic, heavy metals have been well documented on landfills. In addition, many landfill sites are known to have dangerously high pesticide residue levels because of indiscriminate and careless pesticide usage to control ants, rodents and cockroaches, and also because of the cumulative effect of dumping pesticide containers over very long periods of time. A good example is the presence of DDT which can still be measured on some landfills that are over forty years old. Lands which were used for storage of sanitary waste, incinerated waste, burial grounds and from which oil and gas have been extracted should be avoided at all costs since the risks associated with these lands far outweigh their benefits. Further, sites used for garbage disposal or as waste management sites may contain decomposing organic material and human faeces. Areas which are prone to heavy flooding are also cause for concern since the flood waters can introduce chemical contaminants and dead animals from other areas. Dead animals in stagnant water create the ideal environment for the proliferation of dangerous microorganisms. The presence of animals is mainly associated with raw manure. This issue is discussed in Section 4.2 of this document.

3.2 Land Preparation and Topography

Melongene is mostly grown on flat or slightly undulating lands. While the crop can be grown in both wet and dry seasons, farmers prefer to grow the crop in the dry season. In some Caribbean regions most crop production takes place on hillsides. Under hillside production the kind of land preparation techniques that would be employed are different and determined mainly by the need for soil conservation.

3.2.1 Soil types and soil amelioration.

Soil acidity is determined by having a soil analysis done by a reputable soil testing laboratory. By ascertaining the pH of the soil, as well as looking at several other factors, a soil amelioration programme is determined. Reduce soil acidity through the use of limestone.

High soil acidity (pH 3.5-5) impacts negatively on plant growth for the following reasons:

- Concentrations of the potentially toxic elements aluminium, manganese and iron are increased under acidic conditions because of their greater solubilities at low soil pH.
- High soil acidity inhibits microbial activity responsible for organic matter decomposition.
- The efficacy of certain herbicides especially pre-emergent herbicides is reduced.
- Highly acidic clays are less aggregated which results in low permeability and soil aeration.

As stated earlier, the addition of limestone greatly benefits acidic heavy clays. Limestone is beneficial because limestone:

- Reduces aluminium and other metallic toxins
- Improves the physical structure of the soil
- Encourages microbial activity
- Increases the availability of phosphorus, calcium, magnesium and other important plant nutrients
- Provides the soil and crop with calcium

Limestone should be applied 8-12 months prior to production in order for it to benefit the soil and reduce acidity.

3.2.2 Land preparation

The important steps in land preparation are as follows:

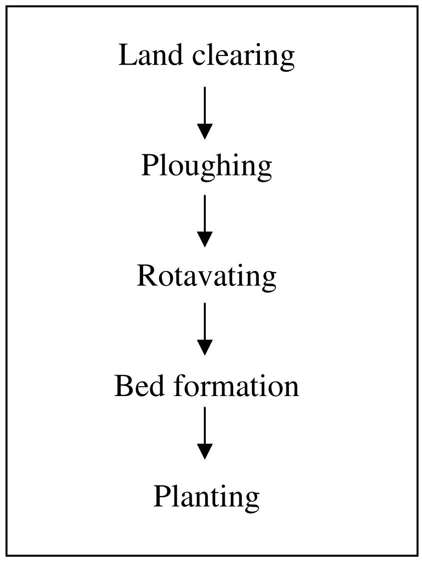

Figure 1: The important steps in land preparation

Land clearing normally involves a number of operations which are aimed at removing vegetation from the land. Brush-cutting and/or the application of systemic herbicides are/is normally used to achieve this end. A deep plough of at least 10-12 inches is made. Some farmers employ the technique called double cutting where the plough is passed over twice on the same piece of land in order to ensure a deep plough.

After ploughing ameliorants such as limestone can be applied before the next operation is done. After ploughing, the soil should be left for 2-3 days since ploughing will cover weeds and prevent sunlight thus resulting in the destruction of some weeds. The soil is then rotavated to a fine tilth and formed into beds.

3.2.3 Bed formation

(a) Flat beds with box drains:

On free draining sandy loams the crop can be easily grown on flat beds. The beds range in width from 2-3 metres and can be as long as 40 metres. On either side of the beds, box drains are constructed to allow for drainage. Most box drains are connected to larger storm drains for quick movement of water after heavy rainfall. During the growth of the crop it is usually moulded at some point along the width of the bed. This practice essentially converts the flat bed to a system of ridges and furrows which facilitates drainage even further. In systems where irrigation tapes are employed two systems of bed formation are quite common.

Figure 2: Flat beds with box drains

Ridges and furrows:

The ridges and furrows is gaining popularity as a method of bed formation. It has the distinct advantage of allowing quick removal of free water after heavy rainfall. Additionally, ridges and furrows can be easily irrigated using irrigation tapes attached to fixed water sources. For melongene cultivation ridges should be 3-4 feet apart. On relatively heavy clays ridges and furrows are very efficient in removing free moisture from the field. After production of one crop the ridges can be rototilled, ameliorants added and another crop can be grown without the need for brush-cutting, reploughing and rotavation.

Figure 3: System of ridges and furrows

3.2.4 Spacing

Like many of the agronomic practices, spacing is influenced by a number of different factors. Generally, however, for flat bed cultivation, plants are spaced 2 ½–3 feet within rows and between 3½-4 feet between rows. On ridges and furrows plants are spaced 2½-3 feet on the ridges and 5-6 feet separates one furrow from the next.

4.0 FERTILIZER USAGE

Inorganic and organic fertilizers are used quite extensively in melongene production. There are guidelines that have been developed when using both forms of fertilizer that prevent risks to human health and safety.

4.1 Inorganic Fertilizers

These are normally applied as compound fertilizers having varying ratios of nitrogen, phosphorus and potassium. It is quite commonplace to find that no soil testing is done before these fertilizers are applied and more often than not there is overuse. The common practice of sharing advice between farmers based on trial and error can lead to one set of recommended practices not being as effective in another situation. Basic guidelines based on the requirements of the crop have been established. These guidelines take into consideration all other aspects of the agronomy of the crop.

A number of fertilizer regimens have been developed. They are recommended following soil testing and making the necessary adjustments to the soil. The general principles that are followed in the determination of a fertilizer requirement for melongene are:

Fertilizer regime:

Fertilizers should only be applied after a proper soil test has been done. The general principles governing fertilizer usage are as follows:

- Apply high phosphorus, chlorine-free compound fertilizer at final rotavation or to the planting hole at the rate of 1 ounce per planting hole.

- After transplanting, apply a high phosphorus fertilizer solution to the newly transplanted seedlings. A good example is a 10: 52: 10.

- Apply a high phosphorus fertilizer every 7-10 days after transplanting up to 6-8 weeks of crop growth.

- At the first sign of flowering apply a high potassium chlorine-free fertilizer at the rate of $1^{1}/_{2}$–2 ounces per plant every 10-12 days. A high potassium foliar fertilizer is sometimes used to prevent flower drop and fruit set.

HAZARDS ASSOCIATED WITH INORGANIC FERTILIZERS

When using inorganic fertilizers or any other agro-chemical it is important to wear gloves that are impermeable to chemical seepage. Allergies that express themselves as skin rashes are known to be caused by some fertilizers. The dyes used on some fertilizers are believed to be carcinogenic to the skin. Protect the skin at all times!

4.2 Organic fertilizers

Organic fertilizers can be derived from both plant and animal material. The use of animal manure is far more common during the production of melongenes than composted plant material. Animal manure may be derived from poultry, small and/or large ruminants including sheep, goats, dairy and beef lot operations, pigs and horses. Of all these forms of manure, poultry manure is by far the most common source of animal manure used in our production systems.

The danger with the use of animal manure is, in almost all cases, these forms of manure are applied raw onto the fields. Animal manure has been well associated with major outbreaks of food borne illnesses worldwide. Animal manure is known to contain very high levels of dangerous microorganisms that can result in human illnesses. These include *Salmonella*, *E. coli* 157:H7, *Cryptosporidium spp.* and the tetanus bacteria, *Clostridium tetani.* In addition, it can be a major pollutant to surface and ground water and to the atmosphere, and is a major contributor to algal bloom on surface water. For these reasons, untreated animal manure used in the production of edible produce implies a greater contamination risk to human health and is not recommended. Animal manure may constitute an important source of plant nutrients if it is properly treated (i.e. composted) before application onto the field. If the manure is inadequately decomposed then the risks will far outweigh the benefits, thus the need for proper composting. It is also important to fallow the land even when composted manures are used in order to further prevent the possibility of pathogen build up.

A very common practice is to broadcast raw manure at the time of planting. Piles of raw manure can be seen on the side of the field of production areas or stored in feed bags . Additionally, feed some farmers top dress the crop with raw manure 1-2 weeks before flowering and fruiting. These practices breach the recommendation of the GAP Protocols and are therefore not recommended. Some simple strategies which can significantly reduce the risks associated with manure usage are:

- Use only properly composted manure
- Abstain from top dressing with either raw or composted manure
- Apply only composted manure to the planting hole 2-3 weeks before transplanting seedlings

The following photographs show a number of the problems associated with improper manure usage.

Figure 4: Raw poultry manure stored next to irrigation channel

Figure 5: Leaching of manure into irrigation channel

Figure 6: Top dressing of melongene with raw manure

4.3 Treatments to reduce risks

4.3.1 Composting

Composting is a natural biological process by which organic matter is decomposed. Bacterial and fungal organisms ferment organic matter reducing it to a biologically stable material referred to as humus. Fermentation generates a substantial amount of heat and this heat reduces and in some cases eliminates the biological hazards. Composting treatments may be divided into two categories: passive composting and active composting.

Passive composting is simply taking the animal waste placing it in a pile and covering it. Over time, microbial activity will decompose the material and the heat generated will destroy the dangerous microorganisms present. This method has the advantages of being simple to do and costs very little in terms of labour. Passive composting is, however, very dependent on ambient temperature and takes 4-6 months before the manure is sufficiently decomposed and safe to use.

Active composting is more labour intensive but results in the material being ready for application into the field approximately 4-6 weeks after decomposition begins. Active decomposition is achieved by making a pile consisting of several layers of different organic material. The following is a formula for 1000 kg of fresh animal manure.

Composting materials: To create 1000kg of fresh animal manure

- 1000 kg fresh manure
- 150 kg dried grass, bagasse, corn stalk etc.
- 50 kg sieved soil
- 10 kg ground charcoal
- 45 kg limestone
- Activator 5kg molasses or sugar mixed with baker's yeast
- Clean water
- Turning instruments
- Water hose
- Thermometer

Add manure over a layer of dried grass

↓

Add soil over the manure

↓

Add limestone carbon activator and sprinkle with water

↓

Mix the material

↓

Form a pile not exceeding 1.2-1.5 m in height

↓

Check temperature at centre of pile after 3 days
(should be between 55-70°C)

↓

Start the turning process

↓

If the temperature is higher than 70°C add more straw and mix again

↓

Daily turning and temperature measurements (55-70°C)

↓

Cover the heap after daily turning for the first 12-15 days.

↓

After first 15 days turn and measure temperature once every 8 days

↓

The process is completed in about 50 days

(A good sign that composting is complete is a fall in temperature to between 40–45°C)

Figure 7: Steps in active composting

4.3.2 Other methods of treating manure

A number of available and evolving technologies can be considered in treating animal manure. The use of biogas digesters greatly reduces the foul odour from the manure making it more comfortable for operators to compost the product thereafter. The methane gas can be trapped and used for other farm operations.

Manure pasteurisation is a new technology that has the potential to destroy harmful microbes. In some systems, manure is dried in layers 3-5 cm thick in open sunlight. The dried manure is then subject to composting producing a product that is free of harmful pathogens.

4.4 GAP in the Management of Organic Manure

Good agricultural practices are critical to the safe use of organic matter. It is necessary to observe GAP when using organic fertilizers. The major components of GAP management for organic matter are:

- proper treatment of the material
- storage of the organic matter
- proper field application
- minimising risks to workers
- record keeping and control

4.4.1 Storage of animal manure

There are some key considerations when selecting storage areas where manure is to be stored and treated. Storage areas:

- Must be kept far away from production areas
- must be contained by brick walls, soil piles etc. in order to prevent contamination by rain wash, subterraneous water flow or wind spread
- Store manure on cement floors
- Must be covered to protect against rainfall. Rainfall generates liquid with a huge bacterial population which can contaminate production areas
- Should be covered and prevented from being contaminated by birds and rodents
- Should be kept away from waste disposal areas

4.4.2 Application of treated manure to the field

Once the manure is properly composted it should be tested for its microbiological safety before it is applied to the soil. It should be applied 2-3 weeks before planting. The risk of contamination is further reduced if the treated manure is applied into the planting mounds on cambered beds and properly mixed with the soil. The common practice of broadcasting raw manure onto the entire field is not recommended.

4.4.3 Hazard to operators

Personnel who handle raw manure must be vaccinated against tetanus. No one with exposed wounds should be allowed to handle manure. After handling raw manure and compost, proper washing ensures prevention of illnesses of workers.

4.4.4 Record keeping and controls

Keeping records of preparation and application of fertilizers are all part of the GAP programme. The information recorded should include the following:

- origin of the organic material
- date composting started and when completed
- temperature recorded during turning
- the physical make up of the composting material
- persons involved in the application
- microbial testing and clearance for usage

5.0 WATER QUALITY

Water quality is an important factor influencing the microbial contamination of fresh fruits and vegetables. Water is essential for a number of operations carried out on the farm including irrigation, pesticide application, fertilizer application and post harvest washing. Additionally, water is required for washing and bathing of farm and packing workers and for drinking. Poor quality farm water can be an important vehicle in microbial contamination of fresh produce.

5.1 Irrigation Water

Critical to the growth and development of pumpkins is proper irrigation and drainage. Severe periods of drought will result in poor yields. Periods of drought followed by sudden watering often causes the fruit to crack thereby providing an additional portal of entry for bacteria and other harmful microorganisms. The marketability of the fruits is also reduced.

The extent to which contamination might occur is also dependent on a number of factors including the method of application of irrigation water, the stage of development of the crop, the type of crop, irrigation intervals and the manner in which the water is stored and handled.

The most common form of artificial irrigation is overhead irrigation. Water is sourced mainly from surface water (rivers, streams etc) which is then pumped into poly vinyl chloride (PVC) or galvanise conduits or via high density or low density polyethylene irrigation tapes and applied to the entire field. It is quite possible that microbial contamination which has been measured in the pulp of pumpkin fruits have affected the fruit as a result of suction of harmful pathogens within the surface water. Current research data indicate a high level of microbial contamination of surface water. Most of our surface water is contaminated with human and animal faeces, industrial and agrochemical pollutants and a plethora of other risks all of which can affect human health.

The following photographs show examples of poor irrigation water at source (Fig. 8) and in irrigation channels (Fig. 9).

Figure 8: Surface water surrounded by potential contaminants

Figure 9: Galvanise conduit with pumping polluted water into production fields

5.1.2 Irrigation tapes

This method of irrigation continues to gain popularity. It is relatively easy to install and with simple plumbing, tapes can be connected to a system of valves that can regulate water flow. This system has the potential to reduce water-fruit contact since the valves can be adjusted to reduce the water's height. When coupled with reducing the water-fruit contact, accessing and treating water to improve its safety and preventing top dressing with manure this form of irrigation can reduce the microbial load that comes into contact with the fruit..

5.1.3 Splash irrigation

Water is led into drains on either side of the bed. The water is then splashed onto the beds using simple receptacles. This exposes the fruits to serious contamination and results in unsightly, dirty fruits with a lot of soil on the surface of the fruits.

Figure 10: Dirty fruits due to polluted water splashing onto the fruit's surface

5.2 The mechanism of contamination: Suction

Melongene has a thin porous peel. Cool, contaminated irrigation water coming into contact with the fruit's surface can result in harmful microorganisms getting into the flesh of the fruit. A similar result is very possible when the field is top dressed with raw manure and irrigation water splashes onto the surface of developing fruits. These microbes are now lodged in the flesh of the fruit and surface sanitising treatments will not have any effect on them. Using alternative irrigation systems such as drip irrigation, safer irrigation water and abstaining from top dressing with manure will reduce this possible source of contamination to a great extent.

5.3 GAP in the Prevention of Water Contamination

5.3.1 Precautions to prevent water contamination

- Identify the primary and secondary sources of water and be aware of the possibility of contamination.
- Ensure that livestock effluent is not an additional source of contamination.
- Be aware of wildlife presence and treat water accordingly.
- Do not store manure in production areas.
- Identify soil topography and rainfall patterns and their possible effect on water contamination.
- Verify water acceptability by periodic testing.
- Store potable water in covered tanks.
- Treat pond and other irrigation water-holding receptacles periodically.
- Choose irrigation systems that prevent water from wetting the entire plant.
- Identify and control the risk of water in packing facilities. Cool drinking water must be available for workers. In some cases where it is not possible to have water from contamination from adjacent fields.

5.3.2 Water harvesting and storage

Contaminated farm water is an issue that requires urgent attention. Contaminated pumpkins will not be fit for human consumption if this issue is not addressed. On international markets where testing is done on an almost routine basis, rejection and subsequent loss of market share will result. Water harvesting, storage and treatment provide the best long term solution to these problems. Several countries including some of the poorer nations of the world are turning to systems that facilitate the collection of rain water in concrete ponds, metal or concrete cisterns, or high density polyethylene collapsible cisterns. Rain water, if properly collected and stored, will carry substantially less harmful microorganisms than contaminated surface water. Rain water will require less disinfection than surface water.

5.3.3 Improving surface water

Most Caribbean islands still have relatively uncontaminated surface water sources. Care must be taken to prevent polluting this scarce but valuable resource. In cases where the only available water source is surface water which may not meet the requirements for irrigation, a disinfection regime must be implemented to allow such water to be used for irrigation purposes.

In order for this water to be used it must first be tested to determine the level of microbial contamination. It is recommended that the water be pumped and stored in concrete ponds or cisterns etc. Attaching the pump to a filtration system at source will reduce the amount of organic matter and so improve the efficiency of disinfection especially chlorine-based disinfection. After testing, the stored water is now subjected to a disinfection treatment using a chlorine-based sanitizer. The water is then tested again to ensure it is safe for farm use. Once the water is determined to be safe for irrigation, recontamination must be prevented.

New technologies are now being developed and commercialized that do not require the use of chlorine. Infrared treatment pumps which use a beam of infrared light to destroy microorganisms have been developed. Such technologies are available but have not as yet been tested in our environments.

5.3.4 Potable water

A ready and available source of potable water must be present at all times on the farm and during postharvest operations. Potable water is to be used for all hand washing, showering, produce cleaning, pesticide mixing and other agro-chemical applications. Cool drinking water must be available at all times to all workers even if it has to be bottled and kept in ice. In order to prepare pumpkins for market the leaves must be washed and sanitised using a chlorine-based sanitizer. During washing, there is direct contact of water on the surface of the fruit's surface and it is critical that this water meets the standard for potable water. Proper washing of the fruits is an essential step before chlorination since chlorine is ineffective when it comes in contact with organic matter and soil.

Chlorine is used to prevent cross contamination and will not sterilise the product. Effective cleaning and low microbial load of incoming leaves will greatly improve the efficacy of chlorine. Chlorine is normally applied at the rate of 100-150 ppm at a pH of 6-7.5. When used properly, chlorine can significantly reduce microbial populations (between 100-1000 fold reductions).

6.0 WORKER HEALTH AND HYGIENE

Workers can be a source of contamination if one does not ensure that the conditions under which they work reduce the opportunity for produce contamination. Contamination can occur both in the field and during postharvest handling operations. Humans can be a major source of pathogens in our food supply. Poor hygiene has been attributed to major food borne illnesses. Personal hygiene refers to practices that promote human health and general cleanliness. Good worker hygiene during production and harvesting will significantly reduce microbial contamination. For this reason, worker health and hygiene must be made a priority on the farm. The following protocols must be established and maintained:

- A food safety training programme must be put in place with periodic training of all farm workers and those who work in packinghouse facilities.
- All workers and supervisors must practise good personal hygiene.
- Field workers must have easy access to clean toilet facilities with proper hand washing equipment.
- All supervisors must be aware of the symptoms of food borne illnesses.
- Sick employees should be reassigned to duties where they are not in direct contact with produce.
- All sanitation practices that are to be followed must be written in a sanitation manual as

part of Good Manufacturing Practices (GMP).

All training must emphasize the relationship between poor hygiene and poor food handling and how these practices impact on human health. Managers and supervisors should not take it for granted that employees understand the importance of good personal hygiene. Workers must be trained in all aspects of health and hygiene as they relate to safe food eg. proper hand washing techniques and proper use of toilet and other sanitary facilities. The importance of reporting illnesses to supervisors must be reiterated since many farm workers may not on their own accord report such illnesses to their superiors.

Effective hand washing procedure

- Wet hands.
- Use soap and rub hands vigorously together for a minimum of 20 seconds to ensure lathering.
- Wash the entire surface of the hand, scrubbing it, including the back of the hand.
- Rinse thoroughly with running, clean, potable water.
- Dry with paper towels.
- Close water faucet with paper towels.
- Open the exit door with paper towel and dispose of towel properly.

When should hand washing be carried out?

- at the start of each work day
- after touching or scratching the skin
- after sneezing or coughing
- after handling dirty equipment or utensils
- before starting to pack or process fresh produce
- after each break
- after handling manure or garbage
- after using toilet facilities
- after handling fertilizers, pesticides ,chemicals or cleaning material

- after smoking

It may not be necessary to train your workers in a formal classroom setting. A one-on-one approach may be more appropriate and can remove some of the fears associated with formal classroom-type training. A training schedule that ensures all workers are trained and retrained goes a long way in ensuring greater compliance with personal hygiene practices In some countries, farmer training facilities offer food safety training and this opportunity should be grasped when it is available.

Other strategies that reinforce hygiene and worker health:

- Place signs at strategic locations to serve as reminders of what is expected.
- Teach employees that uncovered sneezing can contaminate fresh produce.
- Use gloves made of impermeable material.
- Encourage workers to start each day with clean clothing.
- Keep dirty boots and clothing away from fresh produce.
- Do not allow workers to smoke or eat in the fields - saliva could spray onto the produce.
- Encourage workers to use break rooms rather than sitting on the floor or around the facilities.
- Have a well-stocked first aid kit which is replenished on a timely basis.
- Train team leaders and other members of staff in basic first aid.

7.0 CROP PROTECTION

7.1 The Basic Approach to Crop Protection

The protection of crops against pests, diseases and weeds could be achieved by employing non-chemical methods. Where appropriate, the use of biological, physical and cultural methods should be employed with minimal reliance on pesticides.

The basic elements of crop protection are:

Prevention: indirect measures to reduce pest, disease and weed infestation e.g.

- choice of crop/variety appropriate for the location
- use of crop rotations
- use of disease and pest resistant varieties
- mechanical and physical methods of crop husbandry
- good fertilizer and irrigation practices

Observation: methods to determine when action is required e.g.

- routine crop inspection and pest monitoring
- use of diagnostic and forecasting systems (traps, tests)
- use of decision support systems (literature, computer aided devices)

Intervention: direct measures to reduce pests, diseases and weeds to economically acceptable levels e.g.

- cultural and physical control (e.g. mechanical weeding, traps)
- biological controls (beneficial insects, mites, nematodes, BT and viruses)
- chemical control (insecticides, fungicides and herbicides)

7.2 Integrated Pest Management (IPM) Programmes

In all IPM programmes there are seven (7) major components to consider:

- identification of the causes of crop damage
- determination of the factors which regulate pest numbers and plant health
- monitoring of pest populations, their natural enemies and the environment
- determining unacceptable levels of pest damage
  - a decision making framework which uses all available relevant information to determine the actions to be taken
  - implementation of control measures for the selective manipulation of the pest problem
  - further monitoring and assessment. Record keeping.

IPM programmes combine chemical, cultural and biological practices into one programme to control pest populations. Pesticide applications are carefully timed and combined with other pest management practices to reduce the need for frequent pesticide applications. The pest is identified and quantified, the damaged assessed and the pesticide application is made only when needed, using the recommended rate for adequate control. Minimizing the amount of pesticide used, reduces costs and helps protect the environment.

7.3 Pesticide Use and Misuse

The application of chemical compounds to protect and enhance crop yield is a common practice worldwide. Pesticides are chemicals used to destroy all kinds of pests. Depending on the target organism pesticides are classified as:

- insecticides-used to kill insects
- herbicides-used to kill undesired plants
- fungicides-used to kill molds

Pesticides can be extremely dangerous to human and animal health if they are not handled properly. They represent a chemical hazard for workers in the fields, for persons exposed to them and for the consumers of fruit, vegetables and root crops contaminated by inappropriate treatments.

7.4 Selection of Pesticides

Choosing the appropriate pesticide is very important to the implementation of an effective pest management programme. This will also have a direct bearing on the hazards to which the user and other persons and the environment are subjected. Before selecting the pesticide, the pest should be identified and a decision taken as to whether the pest problem is of economic importance, and/or has the potential to become a problem.

Pesticides should be used only when needed and only in amounts that will adequately control pests. The pesticide used must be recommended for the purposes or crops that it was approved for and under authorized conditions, doses and intervals. It is recommended that growers document and verify that the pesticides used come from certified distributors and that competent authorities approve their usage. Table 1 gives a list of pesticides used for the production of eggplants.

Table 1. List of pesticides used in the production of Eggplants

Herbicide	Pesticide/Fungicide
Gramoxone® Round Up®	Primicide®, Fastac®, Padan® Admire®, Rogor®, Admiral®

7.5 Pesticide Handling

Pesticide handling should be controlled through every phase of use, from acquisition through to storage and use in the fields. It is important that the persons in charge of handling pesticides carefully follow the instructions for use printed on the label or on the information page that usually accompanies the product, before the product is purchased, used or discarded. It is important to understand proper handling procedures to assess the impact that the pesticide can have on the surroundings and ground water at the application site.

Additional recommendations for producers handling pesticides include the following:

- Have responsible, well-trained personnel handling the pesticide
- Provide the necessary safety equipment to personnel handling or applying pesticide
- Avoid damages to pesticide containers in order to avoid seepage
- Clearly label containers, transfer equipment and application devices
- Avoid changing product containers to avoid confusion and misuse
- Keep a first aid guide and train personnel to respond to an emergency or accident
- Always have a first aid kit available

7.6 Pesticide Application in the Field

The main pesticide-related hazard for people who work in the fields and surrounding areas lie in the possibility that these substances will harm them through direct contact. These substances can come in direct contact with people through:

- inhalation
- absorption through the skin and eyes
- ingestion
- indirect contact exposure

Pesticides can be applied in liquid, solid or gaseous forms. It is important to have instructions for the preparation, mixing, loading and handling of the specific pesticide being used and the actual conditions of use. The amount of pesticide concentrate needed to treat a specific site should be carefully calculated. Staying within the rate stipulated on the label can help to minimize disposal problems associated with excess mixture and can help prevent ground contamination and/or infiltration into water courses.

7.7 Pesticide Storage

Storage areas for pesticides should be clearly marked. Pesticides are poisons and should be treated as such. Proper storage is essential, not only to ensure a safe working environment, but also to assist in dealing with fires and spillage.

Storage sites should be away from other operations and in a location where in case of an accident, there will be no contamination of water or areas that humans frequent. Storage areas should have concrete floors with smooth finishes and drainage to a sump or other holding area where contaminated water can be decontaminated before release. Storage areas should be dry and well-ventilated.

Pesticides must be stored in originally labelled containers with labels plainly visible. Pesticides must not be stored near food, feed or other items which may become contaminated by spilled material, volatile pesticides, and odours.

There must be no smoking, eating or drinking.

An adequate number of appropriate fire-fighting and safety equipment of appropriate capacity in good working condition should be available in the storage area. Pesticides should be separated into product types (insecticides, herbicides, fungicides etc.) and separate stacking areas allocated for each type. Solid products should be separated from liquid products by segregate stacking.

The storage building should be locked to prevent theft and to prevent unauthorized persons especially children from entering. All operating personnel should be thoroughly familiarized with the use of firefighting and safety equipment and regular practice drills should be conducted.

7.8 Pesticide Residues

Pesticides residues on crops may be hazardous to humans who eat the product. Pesticides do not necessarily cause illness immediately after consumption. However, the periodic ingestion of small amounts of pesticides over extended periods of time can cause many health problems. For this reason high residues on fresh produce are considered as a chemical hazard to consumers. Removal of excessively high pesticide levels from fresh produce is not practical. Therefore the best solution to pesticide contamination is to prevent it from occurring. In the case of agricultural products to be exported, maximum pesticide residue limits for the importing country must be carefully considered. It is therefore important to test the harvested product for unacceptable levels of pesticide residues. These tests can be carried out by chemical analyses in a certified laboratory.

7.9 Pesticide Disposal

The method of disposal of pesticides must be adapted to the facilities available and the prevailing conditions so as not to create problems of human exposure or environmental pollution. One way to avoid disposal problems is to plan carefully - buy and mix only what is needed. If extra pesticide has been mixed it should be sprayed unto another approved crop on the pesticide label. If it cannot be used, it has to be disposed of by diluting the surplus and emptying the contents where it will do no harm.

Empty pesticide containers should not be used to store food, feed or seed. If possible, they should be returned to the agent. Never dispose of pesticides or pesticide containers in discarded wells or near water sources. Empty, rinsed, pesticide containers can be disposed of at the most sanitary landfills. Pesticide containers may be divided into two types:

- containers that will burn-these are usually made of wood, cardboard or paper. Rinse the container several times with water or oil whichever is the more convenient solvent for the pesticide formulation.
- containers that will not burn-these are usually made of glass, plastics or metal. These should be returned to the manufacturer. Containers that have been used to store

mercury, lead or other inorganic pesticides should never be burnt.

7.10 Training and Documentation

The training of personnel responsible for application of pesticides is very critical. They must be aware of the dangers that can occur from the improper use of the pesticides. Safety equipment and knowledge of application devices are important issues. Field workers should be reminded that adverse health effects caused by pesticides are often not noticeable in the short term, but can develop over time where they will become tragically apparent.

7.11 Weed Control

Weeds compete with the crop for light, water and nutrients. If not properly managed, weeds can reduce yields and quality and harbour insects and diseases. Also weeds present in the crop can make harvest difficult.

The use of herbicides can be costly and if not done properly, can cause crop and environmental damage. The grower should aim to plant his crop in a field that is virtually weed-free. Hand weeding during crop growth is recommended.

Weeds should be controlled continually until the crop leaf canopy is sufficiently large to assist in suppressing weed growth. On sloping land, weeds should be slashed and left in place. This provides ground cover, which in turn prevents erosion of top soil and enhances moisture conservation.

Chemical control of weeds is usually the common practice. Contact and systemic herbicides (Table 1) are most regularly used. Systemic herbicides should only be used as pre-emergents for weed control in pumpkin. Strict adherence to the recommended herbicide rate is important. Protective gear should always be worn during mixing and application of herbicides.

Good agricultural practices should aim at reducing the use of herbicides considerably by:

a) identifying and targeting hardy weeds
b) manual methods of weed control

c) frequent use of mechanical weed machines

d) mulching

7.12 Pest and Disease Control

Pest Control

The major insect pests of eggplant in the region are flea beetles *Thrips palmi*, stem borers and aphids. Aphids are small, soft bodied insects which multiply rapidly in a short time. They attack the plants at all stages of growth and are found on the underside of leaves or young stems and growing points. Aphids suck plant sap and make the plant weak. Control can be achieved by using recommended insecticides at the recommended rates. Direct the sprays to the under side of leaves. Admire® applied to the soil after 10 days after transplanting will give excellent control.

Thrips palmi are yellow, tiny elongated insects with rasping and sucking mouth parts. Both adults and young suck sap from the leaves. They cause damage to flowers and fruit, which become discoloured, misshapen and hard. Excessive scarring causes green discoloration on purple fruit. This causes browning or scorching of leaves and also retards the growth of plant and reduces yields dramatically. Thrips are also vectors of virus diseases.

For control, use recommended insecticides at recommended rates. It is advisable to commence application at transplanting and direct sprays to both sides of the leaves. Another means of control are crop rotation.

Table 2.

Common name of Pest	**Control Pesticide**
Flea beetles	Fastac®, Padan®, Admire®
Thrips palmi	Admire®
Stem Borers	Diazinon®
Aphids	Admire®
Lacewing bugs	Fastac®,Padan®,Rogor®

Disease Control

The most serious disease of eggplant in the region is anthracnose: *Colletotrichum spp*. They appear as small sunken spots on the fruit. As the fruit ripens the spots enlarge and become more sunken. This is a major cause of post harvest losses. Fruits with numerous spots will detach from the plant and fall. It is recommended to remove crop residues and burn them since this serves as a good host for the fungus.

Table 3.

Common Name of Disease	Control Pesticide
Verticillium Wilt	(a.i. Methoxybifurcarenone)
Southern Blight	Ridomil® MZ 72 WP (a.i. Metalaxyl/Mancozeb - 8.0/64.0%) Aliette ® (a.i. Fosetyl-Al- 80.0%)
Phomopsis Blight	Daconil® 2 787 W-75 (a.i. Chlorothalonil -75.0%) Dithane® M-45 (a.i. Mancozeb -80.0%)
Anthracnose Fruit Rot	Daconil® 2 787 W-75 (a.i. Chlorothalonil -75.0%)
Alternaria Blight	Daconil® 2 787 W-75 (a.i. Chlorothalonil -75.0%) Dithane® (a.i. Mancozeb -80.0%)

8.0 POSTHARVEST HANDLING: MAINTAINING QUALITY AND ENSURING FOOD SAFETY

Melongenes are highly perishable. Quality loss is first observed as shrivelling of the peel. The fruit has a thin peel and any damage to the peel will exacerbate moisture loss. Under good postharvest management the melongene can be stored for 8-12 days. Under other present systems of poor postharvest handling, fruits show signs of quality loss as early as 48 hours after harvesting. Consumers demand that fruits must be:

- firm with a glossy peel
- dark purple in colour
- free from browning of the calyx and attached stem as these are early symptoms of moisture loss
- free from insect damage

- free from soil
- free from peel scaring caused by mites

Quality can only be maintained if care is taken in all the steps from fruit harvesting to distribution.

The steps involved in the post harvest handling of melongene are as follows:

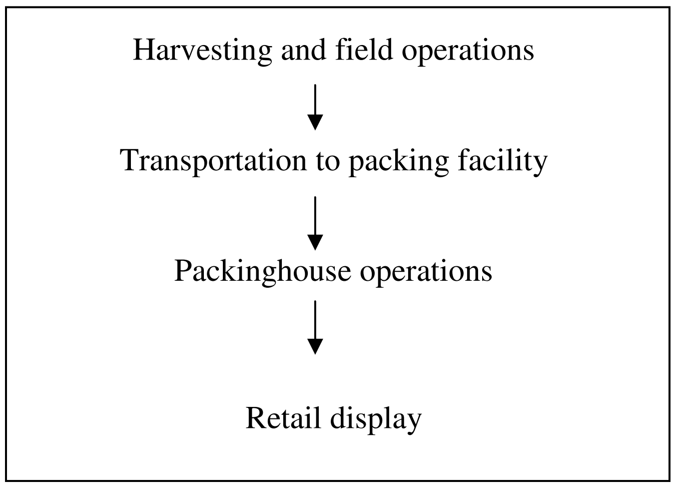

Figure 11: Steps in the post harvest handling of melongene

8.1 Harvesting and Field Handling

Fruits are to be harvested at the correct stage of maturity. At horticultural maturity the fruits feel firm to the touch with an evenly purple peel. Immature fruits even though they are purple in colour feel soft when lightly pressed. Fruits are to be harvested by cutting the stem approximately 3-5 cm above the calyx. A sharp cut is made preferably using a pair of secateurs. Do not cut fruits at a 45° angle as the sharp edges from the stem can puncture fruits during transportation. Fruits which do not meet market requirements are graded out on the field.

Harvested fruits are placed in light coloured harvesting crates with all stems facing in one direction. This practice will reduce the incidence of bruising during transportation. Once the crates have been filled they should be stored in a covered cool area of the field. Failure to follow this recommendation will allow for heat build up and quality loss. If it rains fruits will become wet and free moisture can lead to fruit rotting. A simple shed will help protect fruits from the element resulting in longer shelf life. A simple field shed as shown in the photo below will have a very positive impact on fruit quality if due care and attention is paid to the other aspects of postharvest handling.

Figure 12: Simple field shed

Melongene must never be placed in polypropylene sacks (feed bags) after they are harvested. From a food safety stand point these bags may come from livestock farms and therefore could be contaminated. Even if the stacks are new they are inappropriate as field containers because of heat build up and enormous bruising and compression damage during transportation. Temperatures as high as 55°C have been measured in these bags containing either hot peppers sweet peppers and melongene. Such high temperature will damage the fruit peel leading to excessive moisture loss and shortened shelf life.

8.2 Transportation

During transportation fruits should be placed in a covered tray. This prevents exposure to direct sunlight and rain. Transportation should be done on early mornings or late evenings.

8.3 Sanitizing Harvesting Crates

High density polyethylene crates can be easily sanitized. Sanitization will significantly reduce the risks associated with cross contamination. Crates can be sanitized using the procedure outlined below:

Wash crates thoroughly in running tap water

↓

Apply a food grade degreaser and scrub crates

↓

Rinse with clean water

↓

Dip or rinse crates with a food grade non-chlorine sanitizer

Figure 13: Procedure for sanitizing harvesting crates

Figure 14: Washing harvesting crates

8.4 Vehicle Sanitation

It is quite common in Caribbean agriculture for farm vehicles to be used for a range of different task some of which may compromise the safety of farm produce. Farm vehicles that are used for transporting farm produce should not be used for transporting animal manure and temporary storage for facilitating pesticide operations. These farm inputs can lead to contamination of fruits when they are used to transport fresh produce to packinghouse operations.

Vehicles used to transport fresh produce must at all times be properly washed and the trays sanitised.

Trays can be sanitized using the following simple procedure:

Wash tray with clean running tap water

↓

Scrub with a detergent

↓

Rinse with clean tap water

↓

Final rinse with food grade sanitizer

Figure 15: Vehicle sanitation

8.5 Packinghouse Operations

Most of the packinghouse operations are imposed on fruits destined for regional export, hotels and high-end supermarkets. Fruits sold on the local wholesale and/or retail markets fall woefully short of proper postharvest treatments and high losses due to shrivelling, mechanical damage and rots occur. It is estimated that losses due to the lack of postharvest treatments are between 20-35 % for locally marketed fruits.

On arrival at the packinghouse fruits are immediately removed from the transport vehicle. They are sorted and all fruits which do not meet the requirements demanded of the particular market are culled. Fruits which are culled include: Fruits with slightly yellow peel (this is indicative of over maturity); fruits with insect damage, symptoms of anthracnose, excessive scaring, cracked fruits, mechanically damaged fruits, fruits that are misshapen or immature.

Free water is never used to wash fruits since it substantially increases the likelihood of rotting. Selected fruits are treated by wiping the surface of the fruits with a damp clean cloth. The cloth that is to be used should be sanitized before using and rinsed and sanitized during the operation itself. The fruits are then treated with 100 parts per million (ppm) chlorine. Again a damp cloth is used and the fruits are wiped.

8.6 Modern and Small Scale Packinghouse Operations

In these facilities packing and sanitising are semi-automated. Fruits are sorted and rejects culled. The selected fruits are automatically fed into a machine equipped with soft cleaning brushes and padded rollers. The rollers and brushes are intermittently sprayed with chlorinated water at 100 ppm chlorine. As the fruits pass over the brushes and rollers they are cleaned and sanitized. They are collected at the other end of the machine and placed in cleaned sanitized harvesting crates. The fruits are then loose packed into fibreboard cartoons and placed in chillers held at 14°C. It is important that this cooling operation takes place 4-5 hours after harvesting if shelf life is to maintained.

In cases where the workload is high, fruits should be placed in refrigerated storage on arrival at the packing house and removed in batches sorted, graded, cleaned, packaged and placed in chillers. Chillers which are used for holding fruits must be thoroughly cleaned and sanitized before being reused for storing sanitized fruits. Failure to do so can result in cross contamination. In this regard most modern packinghouse facilities are equipped with at least 2 chillers one as a holding, pre-cooling facility and the other as a temporary storage faculty.

Most modern small scale packhouses are equipped with a piece of equipment that will do the job of cleaning and sanitising semi-automatically. A prototype of the equipment is shown.

Figure 16: Fruits are wiped with clean water and placed on sanitized padded conveyor belt

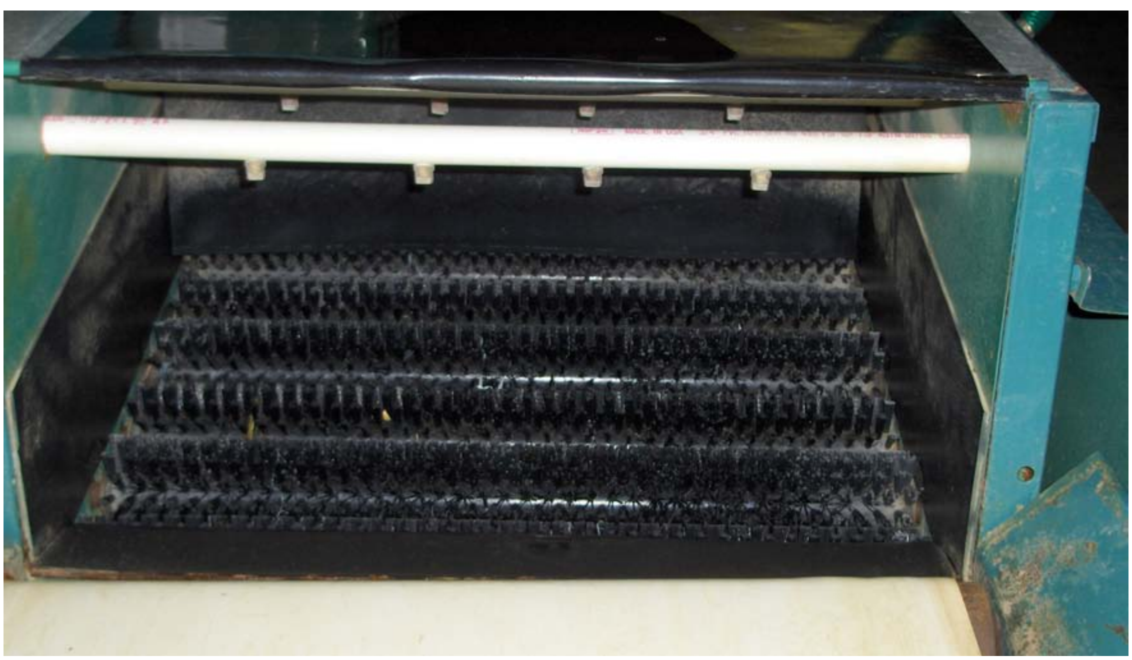

Figure 17: Padded roller brushes are intermittently moistened with sanitizer

Figure 18: Fruits are automatically dried with soft roller brushes

Figure 19: Fruits are collected on a padded turntable sorted and packaged

8.7 Improving Packinghouse Sanitation

Good manufacturing practices form the basis of all food plant sanitation including packinghouse sanitation. Standard operating procedures and standard sanitary operating procedures are the foundation on which microbial and other kinds of contamination are prevented during packing of produce. These procedures are developed written in a sanitation manual. All workers must become familiar with the procedures especially those workers who are in charge of enforcing them. The general principles upon which good manufacturing procedures are built are:

1. Written procedures for sanitising restrooms, breakrooms, waste areas, processing areas, floors and storage rooms.
2. Written procedures for sanitising harvesting crates, palettes and vehicles
3. Sanitising procedures for packinghouse equipment used during washing etc. of fresh produce. The procedures must take into account work benches and sorting tables. These areas are to be sanitized at the end of each work day and at the start of each new day.
4. Sanitation procedures for outside walls, grounds, landscaping etc.
5. Daily sanitation logs for each pre-operational and operational sanitary requirement.
6. Container identification programmes. Containers used at receival, during processing and in the bathroom and kitchen areas must be clearly demarcated.

The following photographs show procedures that have been established to meet the requirements of Good Manufacturing Practices in packinghouses.

Figure 20: Recommended signs for worker hygiene inside a packinghouse

Figure 21: Mandatory footbath used in all modern packinghouses

Figure 22: Clean hand washing bay

Figure 23: Clean washroom facility

Figure 24: Gloves and hairnet to be worn by all workers inside the packinghouse

8.8 Pest Control

It is critical that pests of public health importance be prevented from entering packinghouse facilities. These include cockroaches rats and birds. Birds must be prevented from nesting on the roofs of packinghouses and in receival bay areas. Their droppings carry very high bacterial populations including *E. coli 0157:H7* and *Salmonella*.

Rats carry the *Leptospirosis* bacteria in their urine and can easily contaminate fruits. Workers are also at risk since any contact with rat urine can result in this debilitating and sometimes fatal disease. Rats are generally nocturnal feeders and so it may be difficult to detect them. All measures must be put in place to prevent them from getting into the packinghouse. Some of the measures include:

- Placement of bait stations on the perimeter fence of the packinghouse
- Strategic placement of bait around the packinghouse itself
- Removal of all garbage on a timely basis and sanitization of all bins since rats love to feed on garbage
- Keeping fruits secured above ground and covered
- Provision of baffles at the bases of shelves to prevent the rats climbing onto the surface of the fruits.

8.9 Local Marketing

High postharvest losses and poor fruit quality continues to plague the locally marketed melongene. Poor field containers either polypropylene sacks (feed bags) or woven baskets are used as field containers. Heat damage, mechanical bruising and cuts have all been observed in locally marketed fruits.

No attempts are made to clean fruits before taking to market. Fruits are placed in over stacked open tray vehicles further exacerbating compression bruising and heat damage. Some farmers may wash the fruits with free running water which causes extensive rotting along the marketing chain.

On retail vendor stalls fruits are displayed in a number of different ways

1. Fruits are both placed in stacks uncovered or covered with burlap bags and wetted with water. The free water that is used is often of questionable quality and the storage receptacle often dirty. This causes further rotting and may expose the fruits to pathogens that can compromise human health.
2. Fruits are stored in used cardboard boxes or polypropylene bags (feed bags)
3. Fruits are offered for sale held in woven baskets.

All these different methods compromise fruit quality and food safety. Particular attention should be paid to the use of questionable water at vendor stalls.

Hotels and supermarkets are now starting to place greater demand on the quality of the produce that they offer to their customers. It is quite commonplace to see melongene on the supermarket shelves wrapped in cling wrap. In some cases the fruits are kept at temperature below 12°C and chilling injury results. Once the fruits are kept between 12–14°C they will maintain their quality much better than fruits offered for sale in the retail market situation. Most of these markets now demand a similar quality as that demanded by exporters.

As shown by this series of photographs there need to be improvements in the local marketing of melongene.

Figure 25: Fruits are roughly handled after harvesting.

Figure 26: Harvested fruit left in open sunlight

Figure 27: Inappropriate packaging used to display fruits in wholesale market

Figure 28: Fruits offered covered with damp used burlap bags in the hot sun

Figure 29: Poor quality water used for sprinkling fruits. The receptacles used are also questionable.

9.0 LIST OF ACRONYMS

GAP	GOOD AGRICULTURAL PRACTICES
USDA	UNITED STATES DEPARTMENT OF AGRICULTURE
US	UNITED STATES
ISO	INTERNATIONAL ORGANISATION OF STANDARDIZATION
PRP	PRE REQUISITE PROGRAMMES
GMP	GOOD MANUFACTURING PRACTICES
IPM	INTEGRATED PEST MANAGEMENT
EU	EUROPEAN UNION