GOOD AGRICULTURAL PRACTICES

PUMPKIN PRODUCTION

Ayoub Mohammed

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TABLE OF CONTENTS

1.0 INTRODUCTION

1.1 Importance of adopting Good Agricultural Practices (GAP)

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 important to the fresh produce industry. 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. New supply chain management guidelines include GAP as an essential pre requisite for entry into the market place. In January 2006, the European Union (EU) is set to implement its pesticide initiative programme a programme directly related to EurepGAP. This measure will have tremendous implications for Caribbean exporters whose products are marketed in the European Union. The International Standardization Organisation (ISO) has developed its food safety standard ISO 22000:2005. Good Agricultural practices is the foundation on which the pre requisite programme is based making GAP even more important to the future of trade in fresh produce.

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 GAP compliance programme 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 PUMPKIN IN TRINIDAD AND TOBAGO

The tropical pumpkin (*Cucurbita maxima* Duch.) is an important member of the Cucurbitacae family. Other members of this family include squash, watermelon, cucumbers and bitter melon. Tropical pumpkin is also referred to as calabaza on the foreign markets. The crop is an important part of the local diet and is an extremely important export crop on both regional and international markets. In 2004, Trinidad exported over 2200 tonnes of pumpkin which translates into substantial foreign exchange earnings. Having found a niche on foreign markets, the projection is for increased export earnings in the foreseeable future. This development further reiterateS the need for a sustained effort at ensuring that the GAP protocols are adhered to as stringently as possible. Applying the protocols is almost a prerequisite for gaining further market share in a very competitive export market.

Locally, the crop is an important ingredient in many types of dishes. What is of concern, is the poor postharvest management including less than ideal storage on farms, and poor display at retail establishments. Much remains to be done to improve the postharvest handling on the local market. Research has also shown that the crop has tremendous potential as a fresh cut product and has good eating quality when frozen following the right treatments. Both freezing and fresh cut technologies demand a higher level of hygiene from farm to processing. Of serious concern as well, is the presence of high levels of faecal *Coliform* and *Salmonella* on both the surface and more importantly in the pulp (flesh) of the fruit. Adoption of the principles of good agricultural practices is perhaps the most important protocol that one can use that will significantly reduce microbial and other contamination.

Many farmers grow pumpkins because it takes a relatively short time to produce fruits (between 3-$3^{1}/_{2}$) months. It therefore can be a quick earner of income. Yields are between 8,000-10,000 pounds per acre. Under rain fed conditions it is very possible to get 2 crops per year. Most farmers plant one crop in June/July and the other crop in October/November. Farmers who have access to artificial irrigation systems can produce the crop year round.

2.1 Varieties

Much work continue to be focused on developing varieties that meet the demand of the export market. In many cases what farmers refer to as varieties are really selections based on certain characteristics that meet their particular requirements. Four types that are prevalent on the local market are

Crapaud back : This is a rough skin type with fruits of varying sizes. These fruits are difficult to clean and sanitize.

Iron Cap: A smooth skin type with fruits ranging in weight from 25-40 lbs.

Jamaican squash: Not to be confused with true squash these fruits have thick flesh a smooth thick peel and range in size from 15-40 lbs. It has good demand on the export market.

Sweet mamma : An imported variety with fruits ranging between 10-15 lbs. This is a true F1 variety. It has good eating quality and is widely demanded on the local market.

Musa selection: A rough skin type available from the Chaguaramas seed centre in Trinidad. Fruits range in size from 10-15lbs

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 questions that must be asked 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 following photographs are examples of contaminated water entering a pumpkin producing area.

Figure 1: Chemically contaminated water entering a poorly maintained pumpkin field

Figure 2: Flood water entering a poorly maintained pumpkin field

3.2 Land preparation and Topography

Pumpkins are mostly grown on flat or slightly undulating lands. In some Caribbean regions most crop production takes place on hillsides. In 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

Pumpkins are grown on a range of soil types. Most of the production takes place on heavy clay soils. The best yields are obtained when the crop is grown on a free draining sandy loam with a soil pH of 6.5 7 with high inherent soil nutrients. These fertile soils are rare and therefore production often takes place on soils which must be improved for sustainable pumpkin production. Much can be done to improve these soils to ensure higher yields.

Heavy clays range in fertility from low to high with a soil pH of between 3.5–5. Depending on the clay content these soils crack during periods of very dry weather and become swollen and waterlogged and flooded under sustained heavy rainfall. Heavy clays are normally acidic with a pH range of 3.5-5.5. Important micronutrients are often low especially available soil calcium and magnesium. Additionally microbes tend to fix soil phosphorus resulting in reduced availability of this important plant nutrient. Drainage is often impeded under wet conditions due to soil swelling and large cracks are observed when the soil dries.

Soil acidity is determined by having a soil analysis done by a reputable soil testing laboratory. By ascertaining the pH of the soil, its exchangeable aluminium, as well as looking at several other factors, a soil amelioration programme can be developed. Amelioration often involves 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

Land clearing
↓
Ploughing
↓
Rotavating
↓
Bed formation
↓
Planting

Figure 3: 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 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.

3.2.3 Stale bedding

A common practice is to leave the ploughed soil undisturbed for a few days before the next operation. This allows growth of new weeds which are destroyed before planting.

3.2.3 Bed formation

(a) Cambered beds:

Pumpkins are best grown on cambered beds since they facilitate both drainage and free vining of the crop. Pumpkins must be given sufficient free soil in order for the vines to expose maximum leaf area to sunlight. Cambered beds are between 15-20 feet wide. Properly composted poultry manure is placed in heaps one (1) metre apart on the middle of the bed. Soil is taken from the bed and mixed with the manure forming a mound. This can be done manually or using a rototiller. Broadcasting manure over the entire field is not necessary nor is it recommended although it is commonly practiced. Once properly composted manure is incorporated into the mounds, no more manure should be top-dressed on the field.

Figure 4: Cambered Beds

(b) Flat beds:

Some farmers form flat beds and rotavate only the middle of the beds. This is possible where the soil being used for cultivation is free draining. Seed are directly seeded on the rotavated area or seedlings are transplanted into the middle rotavated area.

Figure 5: Flat Beds

3.2.4 Spacing

Pumpkin is either direct seeded or grown from seedlings. Seedlings that have been properly hardened before planting have shown better survival than direct seeding. Two seedlings are placed in the prepared mounds 3-4 feet apart. If direct seeding is preferred place 3-5 seeds 2-3 cm deep on each mound and cover. Thin out after three weeks leaving two healthy seedlings per mound.

3.2.5 Hillside Farming

When growing the crop on hillsides, soil conservation becomes an important consideration. It is best to develop contour benches 3-4 feet wide. Minimal till is preferred. The only disturbance of the soil is in the formation of the mounds which are made to a fine tilth. Ameliorants are added and either seedlings are transplanted or seeds are directly seeded into the mounds.

4.0 FERTILIZER USAGE

Inorganic and organic fertilizers are used quite extensively in pumpkin 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 pumpkins are:

- The application of a compound fertilizer with a high percentage of phosphorus one week after germination such as 12:24:12 at a rate of 28 grams per mound
- At 3 weeks old apply 28 grams of Calcium nitrate per mound
- At vining apply a high potassium compound fertilizer such as 12:12:17:2 at a rate 84 grams per mound.
- At 8 weeks old apply another high potassium fertilizer such as 9:6:24 at a rate 84 grams per mound.
- Apply a foliar fertilizer such as nutrex 20:20:20 every 2 weeks for the first six weeks following planting.
- Apply a foliar micronutient fertilizer such as Calmax every 2 weeks for the first 6-8 weeks

- Apply foliar fertilizers such as nutrex 20:20:20 every 2-3 weeks for the first 6 weeks of

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. 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 pumpkins 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. Figure 6 shows manure stored near to irrigation channel. Figure 7 shows improper storage of manure.

Figure 6: Bags of manure stacked near to irrigation channel this practice can contaminate irrigation water.

Figure 7: Raw manure next to production site increasing the risk of contamination.

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)

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

↓

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

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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 8: 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 irrigation used in pumpkin production 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 may be as a result of suction of harmful pathogens present in 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. 9) and in irrigation channels (Fig. 10).

Figure 9: Surface water surrounded by potential contaminants

Figure 10: Galvanise conduit taking polluted water into production fields

5.2 The Mechanism of Contamination: Suction

When pumpkins are irrigated with contaminated water using overhead irrigation systems, bacteria from the cooler water can get sucked into the warmer fruit because of the the temperature differential. The suction effect can lead to the accumulation of dangerously high levels of pathogenic microorganisms or the growth of molds which can either cause visible spoilage and reduce the marketability of the fruits especially on international markets. Clearly, the use of systems that directs a cleaner source of water onto the mounds rather than overhead irrigation will greatly reduce contamination due to suction. Suction of wash water during the postharvest handling of tomato fruits has been identified as the cause of an incident of *Salmonella* outbreak. Figure 11 shows microbial growth in freshly cut pumpkin which may be due to either the use of raw manure, the application of poor quality irrigation water or water splashing raw manure onto the fruit.

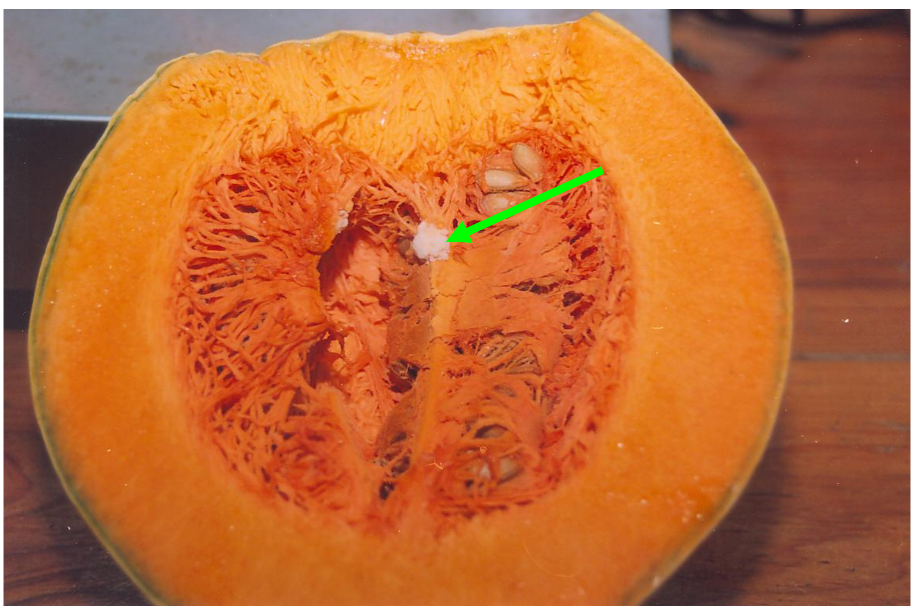

Figure 11: The internal cavity of freshly harvested pumpkins showing mold growth

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. There is a high risk that contaminated fruits can lead to a serious compromise in human health if this issue is not addressed. On international markets, where testing is done on a regular basis, rejection and subsequent loss of market share can 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 fruits 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 reduction).

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 below gives a list of pesticides used for the production of pumpkins.

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

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 herbicide**s** 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

Aphids are considered the major insect pest attacking pumpkins in the region (Table 2). These insects are very common and exist under the surface of leaves. In large numbers they cause yellowing and curling of the leaves and the attendant sooty mold can be observed. Control can be achieved with insecticides such as Admiral, Admire and Malathion.

Table 2. Major Insect Pest of Pumpkins

Major Insect Pest	**Control Measures**
Aphids	Spray at recommended rates with Admire, Admiral, Malathion

<u>Diseases and Control</u>

Gummy Stem Blight *Mycospharella melonis* is considered one of the most serious diseases of pumpkins in the region. The disease is seen as discoloured, water-soaked lesions just above the ground at the seedling stage. The plant eventually shrivels up and falls over. In the older plants, pale brown or gray spots appear on the stems, leaves and petioles. Stem cankers (sores) occur in the area that are just above the soil surface and a light colored, purple gummy ooze is seen. The cankers turn black and agents may affect the lesions that may cause the leaves to turn yellow, wilt and die.

The fungus *Erysiphe cichoracearum* causes Powdery Mildew. The fungus appears as white, pale powdery spots on the upper side of the leaf. Crown leaves are affected first. In the dry season the fungus is spread through the air. It affects the older leaves and young leaves are not attacked. The older leaves turn brown after which they may wither and die. Infected plants are yellow, stunted and may die. Fruits are not attacked but are usually small and deformed. High temperatures favour disease development.

Angular Leaf Spot is caused by the bacterium *Pseudomonas lachrymans*. Symptoms also occur on the stem and fruit, but are less conspicuous. Leaf spots are angular and irregular in shape and size. Spots appear water-soaked at first and later turn gray or tan and finally drop out, leaving ragged holes. Fruit infections appear as small sunken water-soaked spots and fruit rot soon follows. The bacterium which causes this disease, can overwinter on seed and persist in crop residue from diseased plants. Splashing rain and workers can spread the bacteria within the fields. Table 3 shows the major diseases of pumpkins an the chemicals used for their control.

Table 3. Major Diseases of Pumpkins and their Chemical Control

Common Name	**Control**
Powdery Mildew	Daconil® 2 787 W-75 (a.i. Chlorothalonil -75.0%)
Gummy Stem Blight	Daconil® 2 787 W-75 (a.i. Chlorothalonil -75.0%) Dithane® M-45 (a.i. Mancozeb -80.0%)
Angular Leaf spot	Kocide

8.0 POSTHARVEST HANDLING: MAINTAINING QUALITY AND ENSURING FOOD SAFETY

Poor postharvest handling practices compromise both the quality of the fruits as well as increase the risk of food borne pathogen contamination. Postharvest handling consists of several components which must be seen as a systematic series of operations aimed at achieving several objectives including:

- Maintenance of fruit quality
- Reduced incidence of postharvest diseases
- Reduction in moisture loss
- Reducing the risk of food borne illnesses

A good postharvest system involves the following steps:

Harvesting and field operations

↓

Transportation to packing facility

↓

Packinghouse operations

Figure 12: Typical postharvest operations

Postharvest losses occur in the present system because of the following reasons:

- Lack of knowledge by growers of the correct stage of maturity
- Rough harvesting and handling during field operations
- Poor transportation operations
- Poor packinghouse operations

8.1 Maturity Indices

Horticultural maturity coincides with physiological maturity in pumpkins. Fruits are generally harvested by hand. Determination of the correct stage of maturity is critical to shelf life and marketability. Immature fruits have a very short shelf life: they lose water rapidly leading to shrivelling and loss of saleable fresh weight, they have a high propensity for developing post harvest rots, and are easily bruised and damaged during postharvest operations because of an underdeveloped peel or rind. The determination of the correct stage of maturity is essential if one is to obtain the maximum shelf life from this crop. Maturity is determined by looking at a number of characteristics while the fruits are still on the vine. These characteristics include:

(a) Change in fruit colour: Immature developing fruits are shiny green. As they begin to mature the peel (rind) colour changes from green to yellow starting with the ground colour (i.e. the colour of the peel that is contact with the soil). The peel then loses its sheen due to the development of a surface wax.

(b) Change in the stem end of the fruit: At maturity there is corking of the stem with the stem going from light green to brown and the development of a distinct abscission layer (line of fracture). The tendrils nearest to the fruits dieback.

(c) Flesh colour: When assessed objectively there is an intense yellow flesh colour due to carotene synthesis and maximum accumulation of sugars and solids which are well correlated with good eating quality.

(d) Latex flow: Some growers will make a small incision at the stem end to check for latex flow. The absence of latex is indicative of fruit maturity. Once the incision is small enough the rind heals.

8.2 Harvesting and field handling

Care should be taken when harvesting to maintain the integrity of the product along the postharvest chain. Fruits should be harvested in the cooler times of the day - early mornings or late evenings.

Fruits should be harvested by cutting as close as possible to the stem scar without damaging the calyx. This calyx serves a protective function since it is waterproof and prevents the entry of organisms which may cause rots in storage. Fruits with damaged calices will rot very quickly after harvesting. Fruits which have not been properly trimmed will bruise adjacent fruits during transportation. The photographs show the proper and improper trimming of the stem end.

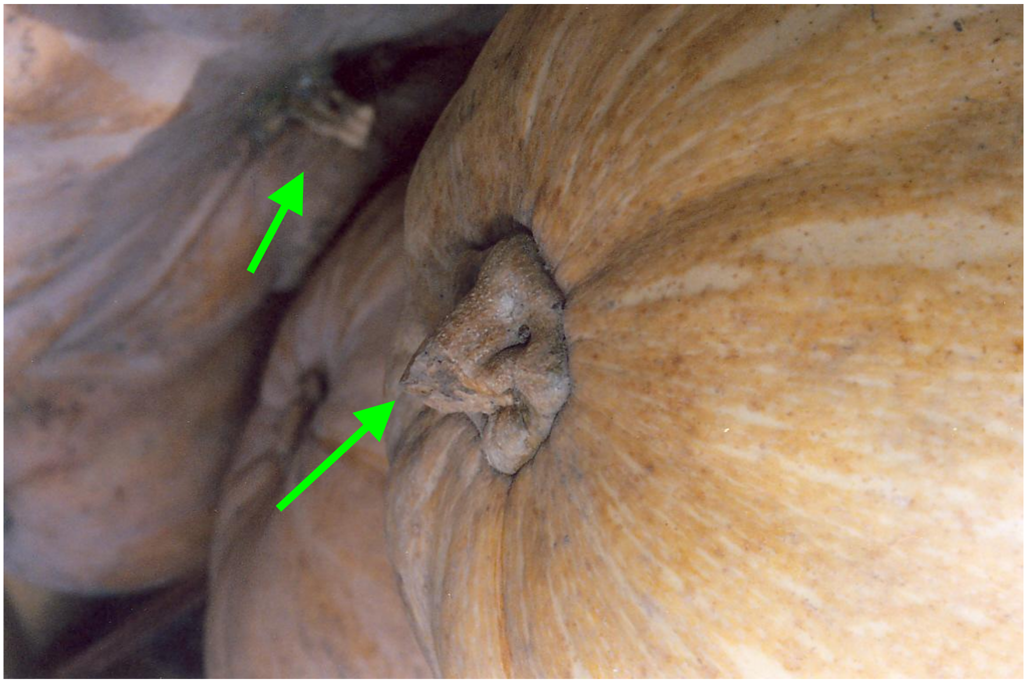

Figure 13: Improper stem end trimming

Figure 14: Proper stem end trimming

8.3 Field packing and transportation

Fruits are harvested by hand and thrown to a catcher on the transport vehicle. Fruits sometimes fall and are bruised. In addition, fruits are roughly placed on the tray of the vehicle which increases the risk of internal bruising. Over-stacking of transport vehicles is quite common resulting in damage to the fruits at the bottom of the pile and substantial bruising on arrival at the packinghouse. In fact, preliminary data has shown, the 25%-40% bruising is due to poor transportation practices resulting in rejection at the packinghouse. In some cases, fruits are transported during the hottest times of the day resulting in high internal fruit temperature and quality losses. High core temperatures result in the product spending a longer time to precool.

8.4 Sanitising 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 15: Procedure for sanitizing harvesting crates

Figure 16: Washing harvesting crates (gondolas)

8.5 Vehicle sanitation

It is quite common in Caribbean agriculture for farm vehicles to be used for a range of different tasks 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 as temporary storage for facilitating pesticide 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 17: Steps in vehicle sanitation

8.6 Local Packinghouse Operations

Most packinghouse operations are done in order to facilitate the export trade. For local marketing very little postharvest treatments are done as fruits are taken directly to wholesale markets or temporarily stored on farms and sold at the farm gate. The food safety concerns associated with local marketing are discussed in another section of this document.

Many of the local, small scale packinghouses do not meet the basic sanitation requirements during postharvest handling and packaging. The hazards that are associated with such facilities include:

- Poor worker health and hygiene
- Poor water quality used for washing
- No postharvest treatments
- No proper washroom facilities
- Conditions which do not exclude pets and birds

On arrival, pumpkins are removed from vehicles and placed on the ground close to where the packing operations are to take place. No attempts are made to properly store fruits probably because visible symptoms of quality loss take a longer time to appear when compared to other kinds of fresh produce. Fruits may be kept on the floor or on dirty wooden palettes for a few days until enough fruits are collected to fill a shipment. Temporary storage on the ground also exposes the fruits to pests of public health importance including rats and cockroaches which are nocturnal in their feeding habits and consequently their presence may not be observed. In addition, poor storage also exposes the fruits to bird droppings. Dead pigeons have been documented on piles of pumpkins waiting to be packaged. Because of its bulkiness, pumpkin is sea freighted in either 20' or 40' reefer containers.

Once the exporter has enough pumpkins they are prepared for shipping. A very basic set of operations is done before packing into refrigerated containers. The basic process flow is given below:

Washing in tap water

↓

Air drying

↓

Placement into netted bags
(On average 2 fruits per bag not exceeding 50 lbs)

Figure 18: Local packinghouse operations for pumpkins

Fruits are often washed in batches in the same plastic container of water. Consequently, after a very short time, the water becomes discoloured due to dirt and other organic material brought in from the field. This dirty water containing food borne pathogens can easily infiltrate the fruits thereby posing a risk to human health. Dirty water will also increase the risk of rotting.

Additionally, workers who operate in these facilities sometimes seem to lack the basic hygiene and grooming required to meet the most basic requirements for good manufacturing practices. Bathroom facilities are often not readily available and workers are not trained in following basic hand washing procedures. All of these situations introduce risks to safe food handling.

Packinghouse infrastructure is sometimes woefully short of the safety requirements for good manufacturing practices. Dilapidated roofing, unsanitary floors, poor storage facilities, inappropriate packaging material, poorly maintained washroom facilities and poor water storage facilities etc. are quite common.

Fruits handled in these conditions result in high losses to the importer. In fact, some shipments arrive in such poor condition that the entire shipment is rejected. A number of reasons contribute to this problem including:

1. Growing fruits in raw poultry manure which itself contributes to fruit collapse during export. High nitrogen is well associated with poor shelf life of some fresh produce.
2. Placing fruits into containers directly without precooling the fruits. The reefer containers that are used are not refrigerated, they are only precooled. The already warm fruits become hot over time resulting in losses on arrival in the importing country.
3. High relative humidity (r.h.) is another concern. Pumpkins should be stored at r.h. of between 65-70%. Higher r.h. results in fruit collapse during storage. Fruits which have not been precooled would have higher respiration rates during storage and therefore the relative humidity of the entire storage area will increase.

The following photographs clearly demonstrate the need for improvements.

(a) Poor packinghouse facility

(b) Batch washing in contaminated water

Figure 19: Local packinghouse operations for pumpkins showing: (a) poor packinghouse facility and (b) batch washing in contaminated water.

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 photographs below 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 packhouses

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 pests include cockroaches rats and birds. Birds must be prevented from nesting on the roofs of packinghouses and in receiving bay areas. Bird droppings carry very high bacterial populationss 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 (Fig. 25)
- 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.

Figure 25: Baiting station for rats

8.9 Local Marketing

Poor postharvest handling practices are common in fruits destined for local markets. These practices include:

- Poor harvesting and transportation: Fruits are harvested with protruding stems, they are overloaded on trucks and are generally roughly handled in the field.
- Poor on-farm storage expose fruits to contamination by rodents, cockroaches and birds.
- In wholesale and retail markets, it is quite common to see fruits on the ground offered for sale either whole, or as cut pieces.
- Fruits are often seen in conditions which allow for contamination by stray animals.
- Fruits are not treated before being offered for retail sale and often have dirt still present on them at retail stands
- At retail stands fruits are not protected from pests of public health importance.

The following photographs show examples of these.

Figure 26: Stray dogs in area of vending stall

Figure 27: Pumpkin offered for sale. These fruits can be easily contaminated by birds, rats and cockroaches.

9.0 IMPROVED PACKINGHOUSE OPERATIONS (THE NAMDEVCO MODEL)

National Agricultural Marketing Development Corporation (NAMDEVCO) is charged with the mandate of marketing (internally and externally) fresh produce grown in Trinidad and Tobago. In an effort to meet the stringent quality demands on export markets, NAMDEVCO established a modern packinghouse facility in 2002. The following procedure was developed at the packinghouse facility for the postharvest handling of pumpkins for export. This procedure can be successfully used as part of a quality assurance programme for pumpkins by any exporter. The basic steps involved in the operations are shown:

RECEIVAL
↓
WASHING
↓
SANITISING
↓
FORCED AIR DRYING
↓
WEIGHING
↓
PACKAGING
↓
PRECOOLING
↓
REFRIGERATED CONTAINERS

Figure 28: Postharvest operations for pumpkin at the NAMDEVCO Packinghouse, Piarco, Trinidad.

On arrival, pumpkins are removed from the transport vehicle, placed in gondolas (large harvesting crates), weighed, and placed in the receival bay. The gondolas are then taken into the packinghouse where the fruits are sorted. Rejects are culled and immediately taken out of the washing area. Rejects include the following:

1. Fruits that have been severely bruised during transport
2. Fruits infested with worms
3. Fruits with damaged calices
4. Fruits that show signs of rotting due to impact bruising or excessive manure usage
5. Fruits showing collapse due to excessive manure usage

Fruits selected for export are first washed in running tap water and scrubbed with a soft-bristled brush. They are then rinsed and placed in a chlorine-based sanitizing solution for 1-2 minutes. The fruits are then air dried and packaged in ventilated netted bags. They are then pre-cooled to a core temperature of 13°C at 65-70% r.h. The fruits are then loaded into pre-cooled reefer containers for export to regional and international markets.

Figure 29: Fruits washed in running water to remove organic matter

Figure 30: Pumpkins being sanitized in a chlorinated dip

Figure 31: Forced air drying of sanitized fruits

Figure 32: Fruits precooled in chillers to a core temperature of 13°C

Figure 33: Fruits loaded in precooled reefer containers after pre-cooling

Figure 34: Worm infestation in pumpkins

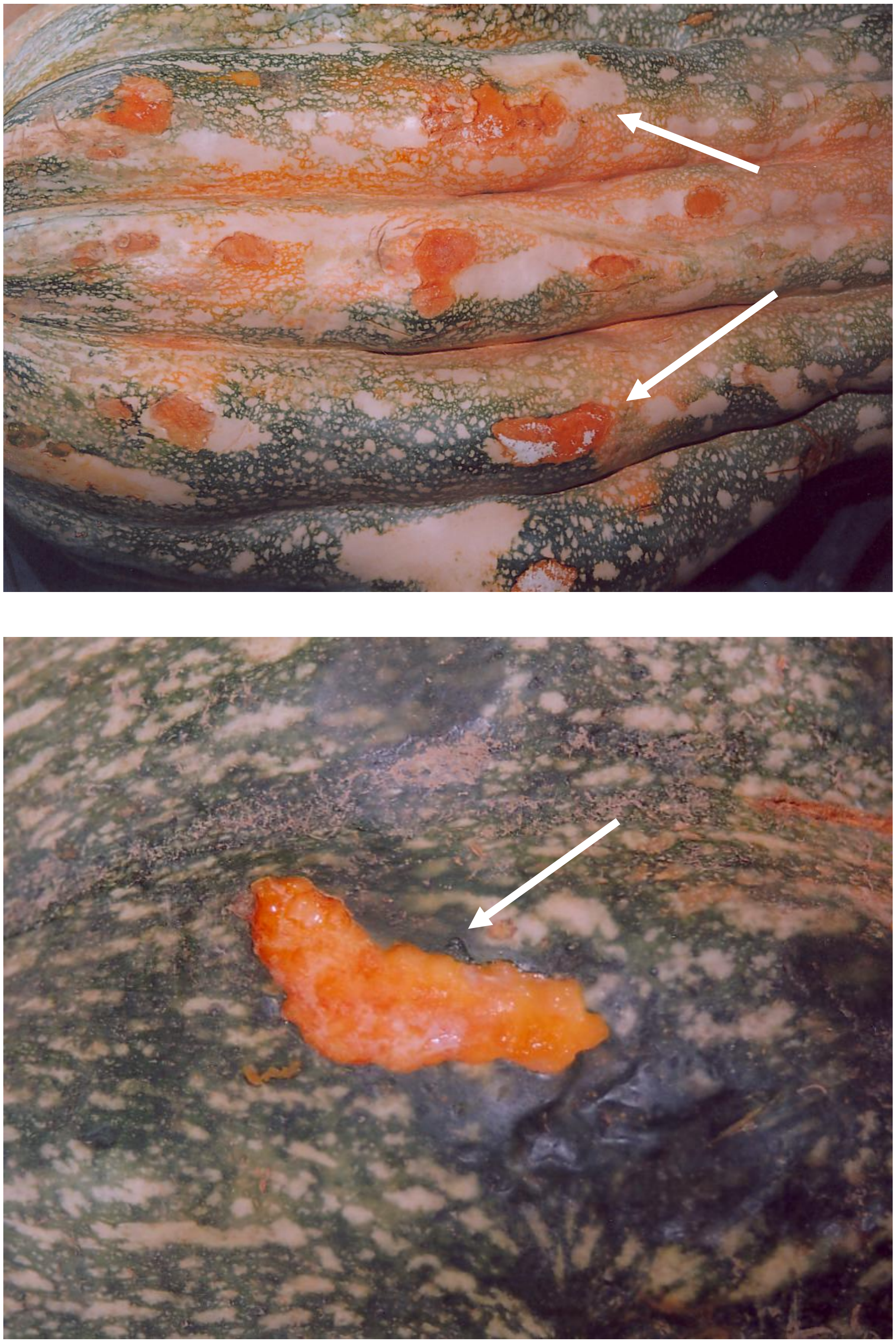

Figure 35: Fruits severely bruised due to poor transportation (Severely bruised fruits will not heal during curing)

Figure 36: Fruit rotting associated with raw manure

LIST OF ACRONYMS

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

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