Chapter 9

Postharvest Handling of Indigenous and Underutilized Fruits in Trinidad and Tobago

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Additional information is available at the end of the chapter

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Abstract

This chapter briefly outlines the origin of some indigenous and underutilized fruit crops found throughout Trinidad and Tobago. It also examines the current situation, current practices, and maturity standards for postharvest handling of these commodities and examines the principle causes of postharvest losses and poor quality. Finally, the chapter includes some recommendations on the best postharvest practices for these indigenous and underutilized fruits, including field harvesting practices, storage and transportation, and cool storage.

Keywords: indigenous, underutilized fruits, postharvest handling

1. Introduction

The present topic is characterized by a large natural population of indigenous and underutilized fruits which despite growing in popularity are on the verge of being extinct as they are not cultivated in large acreages. Several of these crops were consumed as the main fruits by earlier inhabitants in the Caribbean. However, most of them have lost their popularity due to changes in the taste patterns in favor of temperate fruits such as grapes, apples, pears, peaches, and plums. With the growing demand for some of these commodities and possible export potential, there are considerable market development opportunities within the Caribbean for these fruits. The low production of these fruits and the limited information on the postharvest physiology and disease characteristics of these fruits have made large-scale production and packing/processing difficult. The magnitude of postharvest losses of many of these fruits can exceed 50% depending on the commodity as many of them are highly perishable due to high moisture content under tropical conditions [1].

Many of these fruits are harvested, handled, and sometimes processed using local indigenous knowledge at the household level. The main ripe fruits that fall in this category are the edible fresh fruits and include pommerac *(Syzygium malaccense)*, sapodilla (*Manilkara zapota)*, balata (*Manilkara bidentata)*, carambola (*Averrhoa carambola)*, guinep (*Melicoccus bijugatus*), and cashew (*Anacardium occidentale*). The fruits that are harvested mature but do require to be ripened and need to be cooked include breadfruit *(Artocarpus altilis)* and chataigne (*Artocarpus camansi)* and also the palm fruit peewah (*Bactris gasipaes).* There are two edible fresh fruits that are made into frappes or sherbets and ice cream, sweet sop (*Annona squamosa*) and barbadine (*Passiflora quadrangularis*). There is also a very popular root tuber in the Caribbean Latin American countries called topi tamboor leren *(Calathea allouia)*. **Table 1** shows some of the most common indigenous and underutilized fruits in Trinidad and Tobago, their utilization, harvest and postharvest practices.

Crop	Utilization	Harvesting and postharvest handling
Calathea allouia (Aubl.) Lindl. (topi tambo) Plate 1 	• Eaten boiled as an appetizer • Tastes similar to water chestnut and can be used as a substitute • Retains its crispness when cooked • Can be used to make flours	• Harvested after 9 months by using fork to pull up tubers • Tubers can be stored at room temperatures for up to 3 months • Does not tolerate refrigeration • Spoilage in plastic bags at room temperature
Bactris gasipaes (peewah) Plate 2 	• Can be boiled with salt and other spices and eaten as an appetizer • Can also be preserved in brine	• Harvested using coco-knife, sharp chisel, or a sharp luchette attached to picking rods • Can be stored at room temperatures for up to 1 month • Does not tolerate refrigeration • Spoilage in plastic bags at room temperature
Manilkara bidentata (balata) Plate 3 	• Edible fresh fruit • Latex is used industrially for products such as chicle	• Usually harvested in the green to orange stage by picking rods or shaking of trees • Fruits usually have latex which should be allowed to drain • Fruit can be stored up to 1 week at 15°C • Spoilage may occur when left in plastic bags at room temperature

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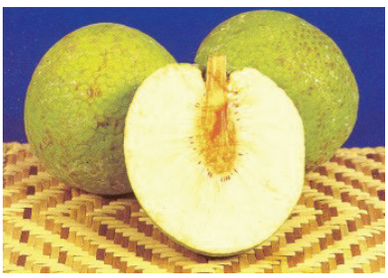
Crop	Utilization	Harvesting and postharvest handling
Passiflora quadrangularis (barbadine) Plate 4 	• Fresh fruit can be made into sherbet or used in desserts • Can also be cooked and used as a vegetable	• The fruits are ready for harvesting when the skin becomes translucent and glossy and is beginning to turn yellowish at the apex • It is clipped from the vine • Very careful handling and packing are essential • Highly perishable
Artocarpus altilis (breadfruit) Plate 5 	• Fruit is usually cooked before eating • Ripe fruit can be eaten as a dessert • Fruit can be boiled, dried, and made into flour, and slices can be fried or stored in brine • The cooked fruit can also be stored • The collected latex can be used as a caulk, glue, and chewing gum	• Fruit stalks must be cut to a length of 1.5 cm and the latex must be drained in the field. • Full green fruits are usually plucked by hand or by a rod. • Fruits can be wrapped in polyethylene and stored at 12°C last about 20 days • Lower temperature causes chilling injury ad higher temperature will allow it to ripen more quickly. • The fruit ripens in 3–7 days • The ideal relative humidity is 90–95% to prevent water and weight loss and shriveling • Well-ventilated cartons should be used and fruits packed in a single layer and separated from adjacent fruits by separators to prevent bruising during transport • Fruit for the local market should also be graded and packed in sturdy crates for delivery • The storage time between packing and delivery to the market should be as short as possible to ensure that the fruit still has a reasonable shelf life when it reaches the consumer
Averrhoa carambola (carambola) Plate 6 	• Fruits can be eaten when fully ripe • Sliced fruits can be added to salads • Can be made into jams, preserves, pickles, candy, juice, and liquor	• Fruit should be firm and crisp with shiny golden-yellow, orange, or yellow skin when ripe. • Fruits are picked by hand • Fruits can be wrapped in tissue paper to avoid rubbing injury • Plastic wraps can also be used • Can be cooled after harvest to extend shelf life • Can be stored up to 5 weeks at 5°C • Moisture loss can occur during storage and can lead to skin browning • Waxing has been reported to be helpful in reducing desiccation

Crop	Utilization	Harvesting and postharvest handling
Syzygium malaccense (pommerac) Plate 7  *Syzygium aqueum* (wax apple) Plate 8 	• The ripe fruit can be eaten fresh or processed into juices	• The skin is thin and delicate and can be easily damaged • Extra care is required when harvesting and handling • Fruits are harvested when the skin has nearly full color and the fruit is firm either by hand or rod • Harvested fruit should be sorted, sized, and packed in a single layer in trays with padding to limit injury • Paper can be used to wrap fruits • The fruit is non-climacteric and is chill sensitive • Fruit can last 4–6 days at ambient temperature • Water loss and sugar content usually declines if fruits are left in polyethylene-wrapped pack at 12°C
Spondias cytherea (pommecythere) Plate 9 	• Harvested either mature-green, semi-ripe, or ripe • It can be eaten fresh or processed into juices or preservatives	• Fruits are harvested when full and light green to yellow by hand or rod • Fruit is climacteric • Fruit must be harvested using the appropriate harvesting tools • Fruits must not be detached from the trees or fall to the ground • Rough handling of harvested fruit must be avoided in order to prevent bruising, cracking, and wounding • Fruit must not be exposed to direct sunlight. They should be kept under shade • Harvested fruits must be transferred to clean and dry plastic crates • Defective fruits, i.e., those that are diseased, mechanically damaged, and otherwise not marketable, must be separated out • Fruit must be cleaned by washing in water containing 100–120 ppm sodium hypochlorite and 0.05% thiabendazole • Surface moisture must be removed by spreading fruit on racks under shade with adequate ventilation • Fruits can be packed into fiberboard waxed cartons • Ambient conditions. For temporary storage under ambient conditions, store in a cool, dry place with adequate ventilation, away from sources of ethylene • Cool storage. Transport and store at 13–15°C and 85–90% relative humidity

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Crop	Utilization	Harvesting and postharvest handling
Manilkara zapota (sapodilla) Plate 10 	• When ripe, the fleshy pulp may be eaten or used to make custard and ice cream called "chicle," and it was this—with the addition of massive amounts of sugar—chewing gum	• Fruits should be harvested when the brown scaly external material from the fruit sheds off • Fruit becomes corky brown in color • Ensure that latex does not flow when the fruit is scratched with the finger nail • Maturity usually judged by size and appearance • Harvest with the use of appropriate harvesting tools and ensure that fruit does not touch the ground • Should be carefully handled as fruit can be readily damaged by abrasion and impact • Mature frit ripens in 3–7 days at 25°C and stored at 15°C for 14 days • Lower storage temperatures lead to chilling injury and a failure to soften • Fruit marketability lessened by low "shelf life" and difficulty of grading for similar maturity
Mammea americana L (mamey apple) Plate 11 	• Can be eaten raw in fruit salads jellies or ice cream	• Harvest by hand and avoid the fruit touching the ground • Perishable during transport • Low temperatures required during handling and sensitive to chilling injury • Controlled and/or modified atmosphere packaging extends its storage life
Annona squamosa (sweet sop) Plate 12 	• Edible fresh fruit • Fruit can be pureed and used to prepare iced drink or mixed with other juices, or it can be made into sherbets and gelatin dishes	• Harvest the fruit by hand when it is fully developed and still firm • The color of the fruit peel changes from dark green to pale green • The fruit is still firm when pressed with the thumb or finger • Can be held after harvest for up to 4–7 days at room temperature before softening occurs • The skin of ripening fruit usually turns dark brown to black, but flesh is unspoiled • Harvested fruits must be transferred to cushioned boxes or crates in order to avoid mechanical damage or bruising • Harvested fruit should not be exposed to direct sunlight, but should be kept under shade • Individual fruit should be wrapped in soft packing material and transported in well-ventilated cardboard boxes • Can be kept for up to 7–10 days at 17°C • Pre-cooling is essential to help extend shelf life

Crop	Utilization	Harvesting and postharvest handling
Musa spp. (silk fig) Plate 13 	• Edible fresh fruit or processed to make ice cream	• Light green to yellow fruits should be handpicked • Highly perishable • Can be stored for up to 1–5 days before spoilage occurs • Cannot withstand low temperatures and should not be refrigerated
Psidium guajava (L.) (guava) Plate 14 	• The fruit can be eaten when ripe • Puree can be used to make juice, cakes, sauces, jams, and jellies and ice cream	• Fruit should be handpicked and not allowed to touch the ground • The fruit is usually grown for processing • Highly perishable • Susceptibility to physical damage, chilling injury, diseases, and insect pests • Mature green and partially ripe fruit can be held for 2–3 weeks at 8–10°C • Ripe, soft fruit can be held about 1 week at 5–8°C • RH of 90–95% is recommended [23] • Shelf life is about 7 days when stored at 20°C

Photo credits: Terry Sampson

Table 1. Some of the most common indigenous and underutilized fruits in Trinidad and Tobago, their utilization, harvest, and postharvest practices.

All these tropical fruits offer many diverse aromas, textures, tastes, and shapes and include many different bioactive compounds. These exotic indigenous tropical fruits and root vegetable products are seasonal crops to a great extent and form part of the diaspora niche markets in Europe and North America. However, because of the poor storage qualities and high rate of spoilage due to the poor postharvest handling, the export potential is not realized. There is a gap in the information for the minor exotic crops and fruits for export which have to be transported over a longer period than the local market.

The commercial success of these tropical fruits depends on the development of postharvest technologies and handling techniques both for marketing locally and export. There are many advances in techniques for harvesting, packing, selection and grading, quality evaluation, transportation, and refrigerated storage conditions and management of postharvest physiological symptoms, insect pest, and microbial decay which must be considered.

It has been reported that the major causes of postharvest losses in tropical fruits were due to fungal pathogens particularly *Colletotrichum* spp. [2]. However, the etiology, biology, and environmental and horticultural factors that contribute to the high infection and development of decay are critical in improving fruit quality and must be clearly defined. It has been

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observed that although tropical fruit crops are cultivated under higher ambient temperatures, they usually have poor postharvest practices, which further affects their shelf life [3]. It was recommended that storage in different packaging materials, viz., micro-perforated polypropylene bags (MPB), micro-perforated polypropylene bags with ethylene absorbent (MPB+K), macro-perforated polypropylene bags coated with antimist coating (PP), fruit waxing, gibberellic acid (GA3), and indole butyric acid (IBA) applications [3].

Many scientific research have been focused on the crop production but little on postharvest issues. However, postharvest quality and shelf life of the fruit in part will depend on some postharvest handling practices and treatments carried out after harvest [4]. Handling practices like harvesting, pre-cooling, cleaning and disinfecting, sorting and grading, packaging, storing, and transportation all play an important role in maintaining quality and extending shelf life. The use of improved postharvest techniques such as refrigeration, heat treatment, modified atmosphere packaging (MAP), and 1-methylcyclopropene (1-MCP) and calcium chloride ($CaCl_2$) has been suggested [4].

This chapter will review and evaluate the applicability and appropriateness of some of these postharvest handling practices and treatment techniques in extending the shelf life and quality and reduction of the losses in some selected indigenous fruits of Trinidad and Tobago.

2. Harvest and postharvest practices and operations for indigenous fruits

Almost all minor tropical fruits are harvested manually, but this physical handling can have a drastic effect on the postharvest quality and shelf life. Most tree ripened fruits are susceptible to rough handling during and after harvesting due to mechanical injuries which reduces postharvest quality and shelf life [5]. The more common handling practices by small farmers include picking, pre-cooling and washing, sorting and grading, wrapping or packaging, transport, and storage.

Small-scale producers throughout the Caribbean usually harvest most of their fruits very early, when fruits are sometimes green to avoid the incidence of praedial larceny (farm theft) [6]. This often results in underripe fruits which have not yet developed their full flavor. Mechanical damage during harvest is therefore not often a serious problem.

The maturation of fruit ready for harvest varies depending on the fruit type which may be harvested in either the matured green, partially ripe, or ripe state [7]. The physiological stages of fruit maturity are the maturation, ripening, and senescence, and they influence the postharvest quality and shelf life. The climacteric fruits are usually harvested at the matured green and then placed in special conditions that ensure their continuation into ripening and senescence. There is little fruit loss during this phase except with physical damage or fruit-fly infested fruits.

The fully ripened fruits are more susceptible to mechanical injuries during harvesting and should be harvested during a cool period of the day to avoid excessive field heat accumulation. The use of sharp tools or containers with edges is discouraged as these bruise and puncture the fruits (**Table 1**).

3. Recommended best practice postharvest treatments

3.1. Pre-cooling and field heat reduction after harvest

There is usually a high build of field heat in the afternoon which is undesirable during the harvesting stage. This increases the metabolic activity that should be reduced immediately after harvest. Pre-cooling minimizes the effect of microbial activity, metabolic activity, respiration rate, and ethylene production [8, 9].

Pre-cooling treatments can reduce the ripening rate, water loss, and decay, thereby preserving quality and extending shelf life of most fruits. It is critical to determine the specific temperature range usually between 13 and 20°C for specific fruits. Pre-cooling can be done by hydro-cooling or dipping fruits in cold water with disinfectants such as thiabendazole and sodium hypochlorite to reduce microbial infections [10].

3.2. Sanitization

Proper hygiene can prevent postharvest diseases and transmission of food-borne pathogens such as *Salmonella*, *Cryptosporidium*, *Cyclospora*, and hepatitis A virus particularly where water is a constraint or likely to be contaminated. Care should be taken to ensure that harvested fruits do not come into contact with the ground to avoid any source of contamination. Disinfection or sanitization in conjunction with hydro-cooling is recommended using sodium hypochlorite solution to reduce the incidence of fungal infection before any postharvest process [11]. Thiabendazole [12] and anolyte water dips [13] have been shown to reduce the microbial infection and maintain superior fruit quality during storage.

3.3. Grading and sorting

Sorting and removal of damaged, infected, or diseased fruits can prevent the production of ethylene in substantial amounts which is capable of affecting the adjacent fruits. When sorting is followed immediately by grading and categorizing of fruits based on color, size, stage of maturity, or degree of ripening, cross contamination and the spread of infectious microbes from discarded fruits to healthy fruits during postharvest handling are reduced. Additionally, through removal, overripen fruits reduce ethylene production and reduce "forced" ripening of the other fruits.

3.4. Packaging

Packaging is done to improve handling, storage, and transport. It involves enclosing the product to protect it from mechanical injuries, tampering, and contamination from physical, chemical, and biological sources [14]. The materials used vary from wooden and plastic crates, cardboard and styrofoam boxes, woven palm baskets to nylon, jute sacks, and polythene bags. However, not all materials give full protection to the fruits [15].

Improper or inadequate aeration within the packaged commodity can result in a buildup of heat as a result of respiration. Similarly, crates or baskets with rough surfaces and edges can

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induce mechanical injuries which will increase ethylene production, thus reducing postharvest quality of the fruits [5].

3.5. Storage

Tropical fruits usually have a very high moisture content and are very difficult to store at ambient temperatures for extended periods without refrigeration. It is critical that storage is extended so that processing operations can provide continuity of product supply throughout the seasons.

Most fruits can be stored for short terms at ambient temperature (10–15°C) and relative humidity (85–95%) [16], provided that ventilation is adequate to prevent heat built from respiration and reduce poor ripening and chilling injuries. However, these conditions in tropical countries are difficult to achieve due to high day temperatures and high relative humidity [17]. On the contrary, very low storage temperature is also detrimental to the shelf life and quality of many tropical fruits and will reduce its flavor, total soluble solids (TSS), and pH of the fruit [18].

It is essential that the correct temperature management is predetermined during storage so as to extend the shelf life of the fruit while maintaining fruit qualities. Storage for short to intermediate time by using evaporative cooling system is recommended.

3.6. Transportation

Farms are usually located away from the marketing centers, processing plants, and inaccessible roads. The lack of proper transportation, like refrigerated vehicles, is a big challenge for both producers and distributors in Small Island Developing States (SIDS). This causes unnecessary delays in getting the produce to the pack houses or market, and such delays can result in losses up to about 20%. During transportation, the produce should be immobilized by proper packaging and stacking to avoid excessive movement or vibration or heat buildup, if transport is not refrigerated. Refrigerated trucks are not only convenient but also effective in preserving the quality of fruits. But it has a high initial investment which is usually unaffordable in SIDS.

4. Selected postharvest treatment techniques

After harvesting, fruits remain living, and all the metabolic process and functions of living tissue continue. However, the postharvest quality of the fruits at or after harvest cannot be enhanced by any postharvest technology, except fruit color, but can be maintained or prolonged.

4.1. Refrigeration storage

Refrigeration is one of the most common effective methods of preserving the quality of many fruits for several days. Low fruits placed at storage temperature can protect quality attributes

like texture, nutrition, aroma, and flavor in many harvested fruits and extend shelf life. However, some fruits are sensitive to chilling injury when they are stored below their critical temperature (10°C) for even short durations and may result in pitting, uneven ripening, and fungal infestation of stored fruits.

The required optimum temperatures (10–15°C at 85–95% relative humidity) can be achieved by using less expensive methods of cooling such as an evaporative cooling system [19]. Where, air temperatures can be decreased (16°C, 91% relative humidity) without significant deterioration due physiological weight loss.

4.2. Postharvest heat treatment

Postharvest heat treatments using hot air and heated water have been reported to reduce chilling injuries in fruits like mangoes and oranges. Heat treating (37–42°C) prior to cold storage can slow down ripening while increasing pathogenic resistance enhanced or caused no change in some quality traits particularly in modified atmosphere storage system. Heat treatment before cold storage at 14°C can also increase TSS and titratable acids (TA) when fruits ripened as compared to the untreated fruits.

4.3. Modified atmosphere packaging (MAP)

Modified atmosphere packaging (MAP) is a packaging technique of using packaging materials with predetermined composition of gases (O_2 and CO_2) after which there is no active effort of modifying the storage space. The materials allow for diffusion of gases through them until a stable equilibrium is reached between the external gases and those inside the package.

MAP materials used include polyethylene terephthalate (PET), low-density polyethylene (LDP), high-density polyethylene (HDP), polyvinyl chloride (PVC), polypropylene [20], and polystyrene [21, 22].

MAP provides a modified atmosphere to control ripening, reducing water loss in stored products reducing mechanical injuries, and reduces the spread of food-borne diseases [23]. The water loss and subsequent shriveling of fruits in tropical regions are two of the causes of their deterioration. However, maintaining excessively high levels of relative humidity inside the package can result in moisture condensation on the commodity, which will in turn create a conducive environment favorable for pathogenic activities, thus increasing the risk of fruit deterioration.

4.4. Methylcyclopropene (1-MCP)

Treatments of 1-methylcyclopropene (1-MCP) can suppress the action of and reduce the rate of ethylene production in harvested climacteric fruit [24]. Fruits with high metabolic activities usually have a shorter shelf life, and any attempts to slow down the metabolism will increase the shelf life. The reduced metabolic activities are closely associated with the ripening process such as color change, cell wall breakdown, and respiration rates and are advantageous to extending storage life [24] and the prevention of abscission in fruits [25].

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4.5. Calcium chloride ($CaCl_2$) application

The pre- and postharvest treatment of calcium chloride ($CaCl_2$) has been shown to improve shelf life and quality of many fruits [26] by delaying ripening and senescence, reducing respiration, maintaining firmness, and reducing physiological disorders [27, 28].

It has also been shown to reduce fungal and other microbial infections and maintain the structural integrity of cell walls, delaying softening and extending shelf life by 4–5 weeks [29]. It also aids in maintaining the quality of fruits by reducing the physiological disorders, increasing the fruit firmness, delaying ripening process, and prolonging the shelf life [30]. Fruit color loss is also delayed, and ethylene production is reduced by 92% [26] while maintaining higher firmness levels during storage. $CaCl_2$ is a very cheap and cost-effective soluble salt which can be dissolved easily and used in the pre-cooling or cleaning of the fruits after harvesting.

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