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Vegetable Crops: An overview of the Processing and Storage Methods

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ABSTRACT

Year-long supplies of fresh food have been made possible by improvements in controlled storage conditions, shipping and importing. A fresh weekly food supply at the local supermarket has eliminated the need for the home preservation and food processing of earlier days. Today, we may choose to preserve and process food for reasons besides availability such as the price of food, quality and nutrition. For these reasons, gardeners who find themselves with a surplus of fresh produce at the end of the season may decide to store and preserve. When conditions are not suitable for storage or immediate marketing of fresh produce, many horticultural crops can be processed using simple technologies. There are some processing methods that can be used by small-scale handlers, including drying, fermenting, canning, freezing, preserving and juicing which are highlighted in this review. Fruits, vegetables and flowers can all be dried and stored for use or sale in the future.

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Introduction

The major sector of the Nigerian economy is agriculture, providing more than 30 percent of the total annual GDP and employing more than 70 percent of the labour force (Adegboye, 2004). Yearly, farmers produced a lot to boost the economy but most are lost at post-harvest stage (Olayemi *et al.*, 2011).

Fruits and vegetables are perishable crops produced by farmers and contain 65 to 95 percent water. When food and water reserves of these crops are exhausted death and decay result. Anything that increases the rate at which a product's food and water reserves are used up increases the likelihood of losses. Increases in normal physiological changes can be caused by high temperature, low atmospheric humidity and physical injury. Such injury often results from careless handling, causing internal bruising, splitting and skin breaks, thus rapidly increasing water loss.

Transport is regarded as an important factor involved in agricultural development all over the world. It is the only means by which food produced at farm site is moved to different homes as well as markets. Transport creates market agricultural produce, enhances interaction among for geographical and economic regions and opens up new areas to economic focus. Losses directly attributed to transport can be high, particularly in Nigeria. Damage occurs as a result of careless handling of packed produce during loading and unloading; vibration (shaking) of the vehicle, especially on bad roads; and poor storage, with packages often squeezed in to the vehicle in order to maximize revenue for the transporters. Overheating leads to decay, and increases the rate of water loss. In transport it can result from using closed vehicles with no ventilation; stacking patterns that block the movement of air; and using vehicles that provide no protection from the sun. Breakdowns of vehicles can be a significant cause of losses in some countries, as perishable produce can

be left exposed to the sun for a day or more while repairs are carried out (Dixie, 2005).

Not only are losses clearly a waste of food but they also represent a similar waste of human effort, farm inputs, livelihoods, investments and scarce resources such as water (World Resource Institute, 1998). Major technical roles of agricultural sector are the reduction of food losses, as a result of mechanical damage in particular, and the enhancement of food safety and quality.

However since most of the mechanical damages to perishable crops occur in transit it is therefore necessary to address food losses from this stand point. The objective of this paper is to give measures against damage of plant perishable produce on transit.

Perishable Plant Produce

Any product that degrades in quality over time is considered perishable. Perishable goods need to be handled in a careful but efficient manner; they need to get from producer to consumer while still in useable condition. Any business dealing in perishables need a cost-effective method of transporting perishable products before they spoil.

The term perishable produce encompasses fresh fruits, vegetables, meat, dairy and egg. These items need to be shipped under strictly-controlled temperature and storage conditions. Dried, canned or otherwise preserved foods are not considered perishable and therefore do not require such strict shipping and handling conditions. They can be stored for longer periods of time and at warmer temperatures since there is no risk of spoilage. Some shipping companies will handle live plants and animals as perishable goods as well.

Transportation of Perishable Plant Produce

Whether you are moving produce from your farm to the market or from the market to your catering gig, making sure your fruits and vegetables arrive as fresh and delicious as the day they were picked is critical. Refrigerated trucking is ideal, but plenty of lowtechnology, inexpensive preservation methods keep produce looking appetizing for short-term road transport. Different types of produce have different requirements but one rule remain constant: cool the produce off, keep it cool.

High wastage is experienced during transport due to high ambient temperatures which accelerate ripening and spread disease, improper containers, careless loading, stacking, rough handling and poor roads. In particular, high temperature causes hest to build up in fruit loads stored in jute baskets as it promotes respiration and transpiration. These factors in turn enhance the growth of spoilage microflora causing rapid decay and loss of quality.

Transit delays are often experienced due to the breakdown of trucks between the farm gate or collection point and the market. Reloading and primary marketing as well as the final journey to terminal markets at cities extend the distribution time so that fruits become over ripen and mealy at the retail stage.

Temperature management is critical during long distance transport, so loads must be stacked to enable proper air circulation to carry away heat from the produce itself as well as incoming heat from the atmosphere and off 'the road. Transport vehicles should be well insulated to maintain cool environments for pre-cooled commodities and well ventilated to allow air movement through the produce. During transport, produce must be stacked in ways that minimize damage, and then be braced and secured. An open air vehicle can be loaded in such a way that air can pass through the load, and provide some cooling of the produce as the vehicle moves. Travelling during the night and early morning can reduce the heat load on a vehicle that is transporting produce. Drivers of vehicles used for shipping produce must be trained in how to load and handle their cargoes. There tends to be a large turnover in drivers (in the US the average time on the job is only 3.5 years) so training is a constant concern (Hagen, et al., 1999). **Damages to Some Fruits and Vegetables**

The following notes highlight some of the major problems

of the more important commodities in the fruit and vegetable group. They are, however, indicative rather than exhaustive.

Bananas and Plantains

Harvesting is generally a one-man operation which frequently results in bruising and abrasions of fruits causing accelerated ripening and consequent decay. Latex staining is prevalent during mishandling. Bunches or hands are often piles one on top of the other without proper protection and fingers are easily detached and often times wasted during transport. This is particularly true of the very open, loose bunches of certain plantain cultivars. In container transport loosely packed hands suffer considerable damage, especially on rough roads. In transit ripening and decay are usually high, notably over long distances (Harvey, 1978).

Mango

Fruits are usually harvested at the time of the day when maximum latex flow is favoured. Latex stain is allowed to dry on the peel, hence immediately reducing consumer acceptability during retail. The collapsibility of the non-rigid crates often used for transport further aggravates quality lose by compression and bruising. The inaccessibility of production area to roads causes serious delays in transport, in addition to a mixed-cargo typo of transport. Stacking in vehicles often does not provide for adequate ventilation. Loading and unloading operations are rather rough. Cold storage is not usually practiced. Ripening is mainly aimed at improvement of the appearance for sales purposes and not for maintaining quality (MA, 1965).

Papaya

Picking poles injure the fruit and there is a relatively high percentage of fruit dropping on the ground, causing breakage and bruising of ripe fruits. Peduncles are not usually trimmed hence injuring other fruit within the pack. Rigid containers are not adequately lined, and within a single pack fruits of assorted sizes and maturity stages are often found. In bulk transport fruit e arc piled one on top of the other without any suitable padding materials. High percentage of decay, particularly anthracnose, is the main problem during ripening and in retail (MR, 1965).

Citrus

Improper time of harvesting greatly enhances rind injury or oleocellosis. Leaving long stubs on fruit injures other fruits within the pack. Containers used are large and over packed, generally without sufficient ventilation. Containers are piled high with the bottom crates bearing the full weight of crates on top. Delays in transport due to poor roads often cause overripening or yellowing of the commodity. Poor storage conditions favour decay and physiological disorders such as chilling injury can also occur if cold stores are not wolf managed (Harvey, 1978).

Grapes

These are attacked by *Botrytis*, *Cladosporium* and *Alternaria* during storage. However, if the storage temperature is strictly maintained between 0° and 2°C, fungal attack can be reduced to a minimum other loss factors could be berry drop, bruises, injury, water loss, and cracking of berries. Selection of unsuitable container type for packaging of grapes may also lead to heavy transit losses. Transit delays, adverse weather conditions and improper type of carriages, e.g., steel wagons, particularly during hot months may further aggravate transit losses (MR, 1965).

Tomato fruits

These are usually picked when fully ripe, and are therefore very susceptible to cracking, bruising, and consequently decay. Packaging containers often used are deep bamboo crates with insufficient aide reinforcements allowing jarring and compression during transport. Loading and unloading operations are very crude. Handlers tend to throw the pecks rather than lift them gently, on account of their weight. During retail sellers tend to pour the contents of the pack into another container, rather than transferring the fruit gently, thereby increasing bruise damage. Fruit a at the breaker stage are mixed with the fully ripe or three-quarters ripe fruits reducing the market value of the pack. Shrivelling percentage can be high since fruits are often exposed to the sun (MA, 1965).

Onions

Insufficient grading is still existent. Spouted, injured and partly decayed bulbs are usually mixed with sound bulbs in a pack. The use of slatted wooden creates is advantageous, especially during transport. Mesh bags of 40-50kg capacity are also used. Sacks are thrown rather than lifted, on account of their weight. Packs are piled one on top of the other with no provision for adequate ventilation. Pre-harvest spraying with sprout inhibitors is seldom practiced resulting in serious sprouting during storage (Harvey, 1978).

Cabbage/Lettuce

Improper harvesting tools contribute greatly to damage to the produce. Trimming of outer leaves is usually not practiced. In container transport, large crates are used (50 kg. capacity). 41289

Bruising and tearing of the leaves is of common occurrence due to the sharp edges of the containers. Containers are piled one on top of the other with the bottom crates carrying the weight of the heads above. Bulk transport likewise results in higher losses (Harvey, 1978).

Peas and Beans

Factors such as the method of packing, suitability of containers, mode of transport, distance covered, number of transhipments, handling, and storage facilities in the consuming centre, all contribute to the degree of loss reported (M.A 1965).

Pepper

Dried pepper should be transported in areas which exhibit the lowest temperatures during the voyage and are dry. In any event, storage beneath the weather deck or, in the case of shipping in containers, in the uppermost layer on deck, must be avoided as the deck or container is strongly heated by the intense tropical sun and, at temperatures greater than 25° C, essential oils may be lost and there is a risk of self-heating. At temperatures greater than 40° C, the product dries out by more than 0.5%. If a container is exposed to direct solar radiation, the product may dry out by up to 2% or more. In the hotter parts of the year, the temperature difference between the port of loading and unloading may be $15 - 20^{\circ}$ C. In the colder parts of the year, however, it is above 30° C.

Incoming cold air may cause sudden drops in temperature which, especially in container interiors, may result in a considerable increase in relative humidity. In this situation, low product water content is of vital significance since the higher the water content of the product, the higher the equilibrium moisture content vice versa (www.greenpepper.com).

If the relative humidity of the container air increases its dew point also increases. At relative humidity levels of less than 100%, the dew point is below air temperature. However, if relative humidity reaches a value of 100%, the dew point is the same as the air temperature and condensation occurs. Corresponding values may be obtained from the psychometric chart.

A rapid and major drop in external air temperature can easily reduce the temperature of the container walls/ceiling to below the dew point of the internal air. This results in the formation of condensation on the internal surfaces of the container which drips onto the cargo and may cause damage due to the formation of wetness, mould, self-heating (www.greenpepper.com).

Measures Against Perishable Plant Produce On Transit Packaging

Packaging is used to protect products and allow them to be received by end users in good quality condition. For most operations involved in the supply of products to remote communities, packaging will not be an issue and packaging provided by packers and manufacturers will be accepted as adequate. However, because of the harsh transport conditions and need to consolidate small quantities of a wide range of products, some additional packaging maybe required to prevent damage and losses. Care needs to be exercised in any repackaging, to ensure that product conditions are maintained, e.g.; ventilation is not restricted, sealed plastic bags or boxes are not used for respiring products (Thompson, 2002). Packaging factors that need to be considered when transporting product include: ➤ Ventilation

➢ Product protection (protection against contamination and physical damage)

- > Strength
- ➤ Insulation
- ≻ Labelling

Some of the important characteristics of various types of packaging include (Thompson, 2002):

1. Fibreboard boxes. The strength of fibreboard boxes can be quite variable depending on construction and the type of fibreboard used in their construction. Overall strength and particularly wet strength will be significantly increased when they are wax coated. Generally, products packed in fibreboard cartons rely on the wall strength of the carton to prevent damage to the products inside and hence retaining wall strength is important, particularly when loading, transporting &unloading product.

2. Polystyrene boxes. Add extra insulation to products that are temperature sensitive, but can be susceptible to cracking.

3. Hessian sacks and net bags. Allow air-flow through the packaging of chilled or dry products. They provide little or no physical protection for the products and should only be top loaded on pallets.

4. Plastic bags or containers. These prevent air-flow to the product during transit (unless perforated), and can be used to maintain a modified atmosphere around the product. Care is required in handling these products, as a break in the bag will destroy the package atmosphere, which can significantly reduce the product's shelf life.

5. Pre-packed Products. Some products may be shipped in small consumer ready pre-packs. These should be packed into fibreboard cartons or plastic crates for convenient handling and to prevent damage during transport and handling.

6. Wooden or plastic bins. Allow for bulk transport of heavy products. They are also useful for the consolidation of small volumes of mixed product lines which are difficult to stack onto pallets in a stable manner. If possible odour producing products should be packaged to prevent odours from escaping. **Palletizing**

Avoid stacking cartons in a manner that reduces the cartons rigid wall strength.

> Avoid stacking raw product on top of processed (ready-toeat) product as this may lead to cross contamination. Also avoid loading ethylene sensitive product on top of ethylene producing products.

> When palletizing, stack light boxes on top of heavier boxes to prevent package collapse and do not stack products so that air flow is restricted.

> Avoid placing products that are not in rigid packaging, e.g.; net/Hessians/plastic bags, on the bottom of pallets and loading cartons or crates with heavy products on top.

> Deteriorated product should be isolated from all other product during transit and in storage to prevent contamination (Thompson, 2002).

Pallet Wraps

Benefits of pallet wraps:

1. Products can be maintained at a lower temperature over an extended period of time.

2. Reduces cost of cooling products, when returned to refrigerated facilities.

3. Maintain the quality of products by reducing the rate of warming or thawing. Be sure to remove wrap prior to returning the products to cold storage, as this will ensure efficient cooling.

4. Wrapping pallets with plastic film will form barriers between various non-respiring products that can help in reducing the cross contamination by odours (Thompson, 2002).

Types of pallet wraps available:

a. Pallet wraps that restrict airflow over and through the pallet will significantly reduce the rate of warming.

b. Simple non-perforated stretch film that has no effective insulating value can halve the warming rate. Any material that has some insulating value like foil wrap, bubble wrap, cotton or synthetic blankets, will further reduce the rate of warming.

When to use pallet wraps:

a. Once product in the cold room is at the required carrying temperature.

b. Immediately prior to transport and removed as the vehicle is being loaded when temperature controlled loading docks are not available.

c. During transportation, product that has been pre-cooled could be wrapped to slow warming of products that may be affected by higher than desirable transport temperatures.

d. At the receivable point, if refrigerated facilities are not available at the receivable point, or the products are not able to be placed directly into cold storage, pallet wraps will slow down the warming process.

Pallet bracing and separation during transport

Pallets should be braced or strapped to prevent boxes from leaning against the side walls, or rear doors of the vehicle. Air inflated pillows are convenient and very effective. Types of braces available include:

1. Strapping – Allows spaces for ventilation as well as preventing pallet movement. It is suitable for frozen and chilled product. Corner protectors should be used to prevent damage to packaging when using strapping.

2. Netting – Allows product to breathe and air movement through pallets, as well as stabilizing movement of products during transit. Suitable for chilled product that needs to breathe as well as those that does not require high humidity atmospheres.

3. Plastic wraps - Prevents air-flow around products, but firmly restricts movement of load. Suitable for frozen and chilled product that does not expel ethylene gas (Thompson, 2002).

Maintaining temperatures on transit

It is important to note that Products must be cooled to the transport temperature before loading vehicles. (See Table 1 for recommended storage and transit temperatures).

The transport vehicle should be pre-cooled to either;

1. Match the ambient air temperature at the time of loading if not using an insulated loading dock or

2. The desired transport temperature if using a loading dock to prevent the products warming from the heat of container walls and floor.

For pre cooling the refrigeration unit should operate for at least 30 minutes or until the inside temperature of the van is at the set temperature prior to loading.

> Be sure to close all doors during pre-cooling to prevent ice build-up on the evaporator coils.

> Temperature control will be negatively affected if there is poor air circulation in the refrigerated van or cold room.

>Broccoli and sweet corn may be packed in contact with (wet) ice to cool or maintain the cooling process.

 \succ If dry ice is being used for products such as dairy and meat, avoid transporting with live seafood, as exposure to carbon dioxide may be harmful.

> Any fluctuations in temperatures during handling may lead to degradation in the product's market quality or could be potentially hazardous to food product safety (Ashby, 1999).

Table 1. Recommended Storage and Transit Temperature for some Perishable Products.

Products	0°C-2°C	4°C-7°C	7°С-10°С	13°C-
				18°C
Dry vegetables	Onions/Garlic			
Fruits/Vegetables	Cabbage	Beans	Okra	Tomatoes
Ethylene	Carrot	Cucumber	Squash	Mature
sensitive				green
	Cut vegetable	Potatoes	Water	
			melon	
	Green Onion	Tomatillo		
	Lettuce			
	Mushroom			
	Spinach			
	Sweet pear			
Fruits/Vegetables	Sweet corn		Bell	Cassava
			pepper	
Not ethylene	Bean sprout			Sweet
sensitive				Potatoes
Fruit:	Coconut	Olive	Grape	Bread
			fruit	fruit
Very low	Date	Orange	Lemon	Grape
ethylene				fruit
Producing	Grape	Tangerine	Lime	
	Orange		Pineapple	
	Strawberry			
Fruit:	Apple	Guava	Avocado	Banana
			pear	
Ethylene	Avocado pear	Honey	Melon	Mango
producing		dew	(unripe)	
	(Ripe)		Custard	Ripe
			apple	tomato
				Papaya
				Plantain

Source: Adopted from Transport and Handling of Perishable Products guidelines, 2011

Maintaining ethylene levels on transit

Ethylene gas is an important ripening agent used by some commercial enterprises before retail distribution, to improve the quality of some fruit. However, to other perishable crops (indicated in Table 1) ethylene gas can lead to a reduction in product shelf life, affect product appearance or induce physiological disorders. As certain fruits produce significant amounts of ethylene, it is important to ensure ethylene sensitive products are not situated near ethylene producing products or that ethylene is removed during storage/transport using commercial ethylene scrubbers (Ashby, 1999).

Ethylene sensitive vegetables should not be mixed with ethylene producing fruits and dry vegetable should not be mixed with other fruits and vegetables. Products listed at temperatures more than 4°C is sensitive to chilling at lower temperatures. All products are sensitive to chilling. Ethylene sensitive fruits/vegetables should not be mixed with ethylene producing fruit (Transport and Handling of perishable Products Guidelines, 2011).

Air Transport

To prevent shifting of the load in a cargo container for air transport, a piece of solid foam or folded fibre-board should be placed along the curved or triangular portion of the floor of the container. Cartons stacked on top will be much better supported and be held upright.

Summary

The importance of Plant Perishable produce cannot be over emphasized, thus need for caution while on transit.

Tips and warnings with regards to transporting perishable produce are;

1. Hydro-cool produce in a sink filled with cold water, or spray sturdy vegetables with cool running water. This step is especially critical to keep leafy greens from wilting but also helps maintain freshness in other vegetables. Exceptions include bulb onions, garlic and potatoes to be stored.

2. Pack produce into sturdy, opaque, breathable containers. Waxed cardboard boxes work well; plastic storage containers with holes drilled in them are also suitable. Fragile fruits and vegetables, such as peaches and tomatoes, should be packed in a single layer.

3. Keep all produce well shaded during transport. Pack containers into a windowless van or truck, or cover them with light plastic or synthetic fabric to help keep the sun off and moisture in.

4. Cool greens and other heat-sensitive vegetables, such as asparagus and broccoli, en route. These and many other heat-sensitive vegetables do best between 35 and 45 degrees F. Pack containers into coolers or insulated boxes with ice or ice packs.

5. When you reach your destination, refresh produce by soaking it in cool water or spritzing it with a spray bottle. Cool to optimum temperature as soon as possible.

Conclusion

The dietary importance of perishable products to man and the losses encountered by the farmers as the result damage in transporting them from the farmhouse to the market have called for proactive measures to be taken to ensure their wholesomeness. The relevant authorities are encouraged to pick up this change through extension agencies, to enlighten illiterate farmers on the most effective ways of handling, transporting and distributing perishable products with little or no damage on transit. Post-harvest losses of fresh fruits and vegetables in Nigeria could be as high as 30-50% depending on the produce.

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