

## KOGI STATE COLLEGE OF EDUCATION TECHNICAL ZERO ENERGY COOLING CHAMBER

Ayegba Fatima Ileadu<sup>\*1</sup>, Durotimi Moses Ayodele<sup>\*2</sup>

<sup>\*1,2</sup>Kogi State College of Education Technical, Nigeria.

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### ABSTRACT

Post-harvest loss is a major problem in cultivation of horticultural crops. The amount of effort put in to produce these crops does not commiserate the profit. Losses for highly perishable leafy green vegetables have been measured to be as high as 70%-80% in West Africa and losses in fruits to be 50%-70%, especially during the rainy season. It is not unusual to find post-harvest losses reported to average 20% to 50% during the period between harvesting and final retail marketing. This amounts to an enormous waste of seeds and planting materials, land, energy, fertilizers, water, labour and other productive resources.

It therefore becomes pertinent to bring about a solution which is the Zero Energy Cooling Chamber. There will be extension services given to community farmers in the Department of Agricultural education. Bricks, bamboo, straw, sand, cement and source of water are the materials needed. A high levelled ground will be prepared while the bricks are laid flat to make a base. Double bricks wall will be laid; the first measuring 1.65m (length) by 1.15m (width) by .67m (height). A cavity of .075m will be left in between the two walls. Sand will then be wet with water and filled into the cavity. A PVC pipe will be fitted on top of the cavity and connected to source water. A lid made from bamboo and straw measuring 1.65m by 1.15m will be matted and used to cover the chamber. A shelter will then be built over the chamber making use of bamboo and straw to protect the chamber from direct rainfall and sunlight. Different fruits and vegetables will be kept in plastic crates and put in the cooling chamber to compare with others that are left under normal environmental conditions.

### 1. INTRODUCTION

Global efforts in the fight against hunger to raise farmers' income and improve food security especially in the world's poorest countries should give priority to the issue of crop losses (FAO 2010). Crop losses indicate the waste of agricultural resources such as land, water, labour, managerial skills and other inputs that could have been channeled into more viable ends.

Roughly about one third of food produced for human consumption is lost or wasted globally, which amounts to about 1.3 billion tons per year (FAO, 2011). More so, 30 to 40 % of the food crops produced in the world is never consumed as a result of damage, rotting as well as pest and diseases which affect crops after harvest (Meena, et al 2009). As such, post harvest loss has contributed to food problem in Nigeria.

Alazar (2007) defined horticultural crops as crops, which are not staple cereals or major industrial crops, but are mainly eaten for their contribution to the flavor and interest of food with flexible consumption based on price, quality and supply. This includes fruits, vegetables, flowers, spices, medicinal and aromatic plants and plantation crops (Choudhury, 2006).

Horticultural crops are essential for a nutritionally balanced diet. Fruits and vegetables are the major source of vitamins A and C, a good source of calcium and iron and they supply part of the requirements for a number of other minor nutrients. Roots, tubers, bananas and plantains are important sources of calories and also supply a number of minor nutrients and some protein. In addition, horticultural crops add variety, enjoyment and a sense of satisfaction with the diet because of their appealing colours, flavours and textures.

Vegetables are essential parts of human diets but are perishable in nature. They are universally known, widely consumed and one of the most important sources of minerals and vitamins in human diet in the world (Nasrin, et al. 2008; Babalola, et al. 2010). Vegetables are edible plant parts which include stems, stalks, roots, tubers, bulb, leaves, flowers and fruits, generally consumed raw or cooked with main dish (IARC. 2003). Examples of vegetables include onion, tomato, okra, pepper, amaranthus, carrot, and melon, among others (Ibeawuchi II., et al. 2015).

Due to the physiological form of fruits and vegetables, they deteriorate easily in transit and storage especially under conditions of high temperature and humidity resulting in heavy losses of these crops (Idah PA., et al., 2007). The main factors that are most consistently related to higher levels of post-harvest losses include rough handling, use of poor quality packages, high post-harvest handling temperatures and delays in marketing (Kitinoja and Al Hassan, 2012; Kitinoja and Cantwell, 2010). Losses for highly perishable leafy green vegetables have been measured to be as high as 70%-80% in West Africa and losses in fruits to be 50%-70%, especially during the rainy season. It is not unusual to

find post-harvest losses reported to average 20% to 50% during the period between harvesting and final retail marketing. This amounts to an enormous waste of seeds and planting materials, land, energy, fertilizers, water, labour and other productive resources.

Post-harvest losses of vegetables are more serious in developing countries. In developed countries losses are generally small during processing, storage and handling because of the efficiency of equipment, good quality storage facilities and close control of critical variables by a highly knowledgeable cadre of managers. In contrast, in developing countries losses in processing, storage and handling tend to be rather high because of poor facilities and frequently inadequate knowledge of methods to care for the vegetables properly. Post-harvest loss of vegetables depend upon the specific marketing channel being assessed which includes variables such as amount of time it takes to market the crop (delays in marketing) as well as the distance to markets (Lisa and Adel, 2015). It therefore becomes necessary to find solution to post-harvest losses of vegetables and fruits among farmers in the host community of Kogi State College of Education (Technical), Kabba, Kogi State.

In tropical areas like Nigeria, tremendous amount of quality deterioration take place immediately after harvest of produce due to lack of on farm storage faculties to overcome this problem, low cost environmental friendly and easy to use storage facilities are to be developed. This does not require electricity. An example of such is the Zero Energy Cooling Chamber. This chambers work on principle of evaporative cooling using locally available materials like brick sand and bamboos. The temperatures in these chambers are less than surrounding atmosphere. These chambers can be used for short term storage of products at the farmers field itself.

On farm storage is also required to reduce losses in highly perishable fresh horticultural produce. Low-cost, low-energy, environmental friendly cool chambers made from locally available materials and which utilize the principles of evaporative cooling will be developed in response to this problem. This cooling chamber is able to maintain temperatures at 10<sup>0</sup>C–15°C below ambient, as well as at a relative humidity of 90 per cent, depending on the season. Fruits and vegetables are stored in plastic crates within the chamber. The shelf life of the fruit and vegetables maintained in the cool chamber was reported to be increased from 3 days at room temperature to 90 days (Anon. 2006).

Storage life is governed by several factors. These include variety, stage of maturity, rate of cooling, storage temperature, relative humidity, rate of accumulation of CO<sub>2</sub>, pre-packing and air-distribution systems. Optimum storage temperature and relative humidity requirements for different vegetables are mentioned in Table 1.

Table 1. Storage temperature and relative humidity requirements for important vegetables

Crops	Temperature (°C)	RH (%)
Tomato (ripe)	8.5-10.0	85-95
Cucumber	8.0-10.5	90-95
Tomato (mature green)	10.0-12.0	80-90
Pumpkin, ginger, sweet potato	11.0-13.0	80-90
French bean, okra	7.0-9.0	85-95
Lettuce	3.0-4.0	85-95
Potatoes, lima bean, cowpeas	4.0-5.5	80-90

Post-harvest loss is more serious as compared to production loss. Reductions of post-harvest losses significantly increase availability of vegetables without bringing additional land into production and without using additional inputs. Although losses cannot be reduced completely, but can be minimised by adoption of modern cultural practices, harvesting, handling, marketing and processing techniques.

## 2. STATEMENT OF PROBLEM

Although human and material resources are devoted for planting, irrigation, fertilizer application, 50% of horticultural crops are lost due to post-harvest loss (Alazar, 2007; Olayemi et al., 2010). Post-harvest losses and quality deterioration of horticultural crops are mostly caused by pests, microbial infection, natural ripening processes and environmental conditions such as heat, drought and improper post-harvest handling (Idah et al., 2007; Olayemi et al., 2010). It occurs through all or at least one of post-harvest activities such as harvesting, handling, storing, processing, packaging, transporting and marketing (Mrema and Rolle, 2002).

Nigeria is Africa's second largest producer of tomatoes with over 1.5 million tonnes harvested annually. Globally, Nigeria ranks as the 16th largest tomato producing nation in the world and has the comparative advantage and potential to lead the world in tomato production and exports. The country accounts for 68.4 percent of West Africa's

output; 10.79 percent of Africa's and 1.2 per cent of total world production of the crop. Despite this, nearly 50 percent of post-harvest losses occur annually due to poor storage system and poor transportation (Omosomi O., 2017).

Reduction of post-harvest losses and quality deterioration are essential in increasing food availability from the existing production. Minimizing this loss has a great significance for food security, economic growth and welfare of the society.

Therefore, this research will be conducted to help farmers and fruits and vegetable sellers to be able to store their produce a little bit longer and so minimises wastage and increase their profit.

### 3. AIMS AND OBJECTIVES

The aim of this research is to construct a Zero energy cooling chamber. The specific objectives are:

- To source for local materials available in the school community
- To determine the shelf life of fruits and vegetables stored in ZECC.
- To train farmers on how to store their produce a bit longer.

### 4. LITERATURE REVIEW

One of the country's agricultural policy trusts specifies that farmers be encouraged to use simple but effective on-farm, off-farm storage facilities and agro-processing technology in order to add value to farm produce and increase their shelf life. In line with this, the Nigerian Stored Products Research Institute (NSPRI) together with Food and Agriculture Organisation (FAO) developed techniques for the storage of fruit and vegetables. Many of the techniques would require high-energy sources like refrigeration which are not available and affordable to the local farmers (Abimbola, 2014). These techniques could help increase the shelf life of the crops and make them stay longer before they are sold.

However, the non-availability of these facilities to local farmers implies that farmers will always have to sell at reduced price as they cannot keep the highly perishable produce for an extended period of time. This has grave implication implications on the income of farmers and could consequently result into rapid decline in their welfare.

The term post-harvest losses are defined as "losses that occur after harvest till the produce reaches consumers. It can be quantity as well as qualitatively losses. Post-harvest losses are more painful and costlier than pre-harvest in terms of money and labour. Vegetables are highly perishable having moisture content of (80-90%). They are live commodities and continue their life processes like respiration and transpiration even after harvest. When the fruit is attached to the parent plant, water and photosynthates are supplied to it. But losses are not replaced during post-harvest stage and hence the produce depends on its own food reserve and moisture content with the result they perish fast. Water is lost from the product due to transpiration and food reserve depleted by respiration. Water loss or transpiration is a major factor affecting quality of vegetables. In addition to lower saleable weight, loss of water can affect quality in many ways, including wilting, shrivelling, flaccidness, soft texture and loss of nutritional value (Nath A. et al, 2018).

The rate of water loss, and the impact of this loss, will vary by product. Water loss can be reduced by cooling products, maintaining a high relative humidity in the storage environment, controlling air circulation, and where permitted, the use of surface coatings or plastic film (Chris and Jacqueline, 2012).

Common Storage method used to preserve most of the produce generated by our ancestors is referred to as common storage. This involves storing harvested produce in a darkened, cold area. There are various ways where this can be done including leaving the produce in the ground, burying it in the ground in pits, storing in cellars or basements and storing in wooden crates or barrels located in cool areas like a garage. In-ground storage, pits and earthen pots are some of the traditional storage systems used for storing fruits and vegetables. Burying in the earth allows for a controlled atmosphere because soil temperatures do not fluctuate - they remain cool compared to air temperatures. Pits, however, must be well drained and protected from rodents. (William, 2020).

Post-harvest technologies include the objectives of maintaining the fresh quality of the produce in terms of appearance, texture, flavor, nutritive value, etc, protecting produce, maintaining food safety, and reducing the average losses between harvest and consumption (Saraswathy et al., 2010). The time a produce is exposed to any adverse condition is generally directly proportional to the decrease of quality of any horticultural produce (Leblanc and Vigneault, 2008).

Most fruits and vegetables are seasonal and perishable in nature. In a good season there may be a local glut followed by famine during off season. Hence, several authors (Adesida 2009 and Adekalu, 2014) have pointed out the need to march all efforts to save crop that are produced from deterioration and waste.

Nigeria climate allows cultivation of fruits and vegetables. However, the post-harvest loss is enormous due to absence of proper storage facilities, farmers are forced to sell their produce at throw away prices (Omolo et al., 2011). This often leads to economic losses occurring in the later part of food chain through excessive processing, packaging and marketing (FAO, 2008). To this end, Booth and Coursey (1972) observed that increased food demand must be backed with focus on reduction of post-harvest losses that will lead to stabilization of prices during the season and off season.

Post-harvest losses vary greatly among commodities and countries. Conservation estimates suggest that out of more than 200 million tons of horticultural crops produced every year over 50% are lost between harvest and consumption (Adekalu, 2014). Minimizing the post-harvest losses have been made through research on the physiological changes of the produce, storage structures, longer shelf-life varieties, suitable cultivation methods, optimum harvest indices, storage environment recommendations, pre-cooling, refrigeration, transportation methods, and improved handling methods. The critical handling point of any commercial fruit and vegetable operation is harvest; this is the starting point for the post-harvest management process.

There are so many causes for losses in the post-harvest food chain that it helps to classify them a number of sub-groups. These are biological, mechanical, physical, biochemical, micro biological and physiological. (Adekalu, 2014). Atanda S.A. et al (2011) stated that secondary causes of loss are those that load to conditions that encourage a primary cause of loss. They are usually the result of inadequate or non-assistant capital expenditures, technology and quality control. Some examples are: Inadequate harvesting, packaging and handling skills, lack of adequate containers for the transport and handling of perishables, storage facilities inadequate to protect the food, transportation inadequate to move the food to market before it spoils, inadequate refrigerated storage, inadequate drying equipment or poor drying season, traditional processing and marketing systems and bumper crops; this can overload the post-harvest handling system or exceed the consumption need and causes excessive wastage.

#### **Temperature management practices**

Temperature management is the most important tool that we have to extend shelf-life of fresh horticultural commodities after harvesting the produce. Temperature management begins with a rapid removal of the field heat by using one of the following cooling methods: Hydro cooling; in package ice; top icing; evaporative cooling; Room cooling; Forced air cooling; Serpentine forced air cooling; vacuum cooling; and Hydro-vacuum cooling.

Proper relative humidity should be 85-95% for the majority of the fruits, 95-98% for vegetables (except dry onions and pumpkins at 70-75%) and 95-100% for some root vegetables.

Optimum temperature for effective storage varies from 18 to 25°C. At lower temperature ripening is slowed, from 25 to 30°C ripening may be inhibited and decay accelerated. Relative humidity should be as high as possible.

Mohammed and Afework (2018) observed poor conditions of fruit handlers, problems related to transportation account for losses of horticultural produce in Ethiopia. Postharvest losses can be caused by a range of factors ranging from growing conditions, to handling at retail levels. Not only are losses clearly a waste of food but they represent a similar waste of human efforts, farm input, livelihood investment and scare resources such as water. The exploratory survey has revealed and identified issues and constraints in reducing post-harvest losses and to define strategies and measures to reduce the losses. This is in agreement with Gudilla, et al. (2013).

## **5. MATERIALS AND METHODS**

Materials like straw, bamboo will be sourced from the host community while bricks and sand will be gotten from the block making industry. Plastic crates, pvc pipes and water container will be bought from Lagos.

#### **Materials**

1. Brick
2. Bamboo
3. Sand
4. Straw
5. PVC pipes
6. Water container
7. Plastic crate
8. Polyethene
9. Jute bag
10. Shovel
11. Rake
12. Cement
13. Saw

14. Nail

#### Procedure

A flat surface area will be marked for the erection of the chamber. This will be levelled using a shovel and spread out using rake. Bricks are laid to make the base of the chamber.

Bricks will be laid one on top of the other making a rectangular shape. This will measure 1.65m x 1.15m (Length and breadth) with the height of 0.65m. After the first layer, another is laid with a cavity of 0.75m.

The core is then filled with sand to the brim. The plastic crates are then put inside the chamber. The crate with the fruits and vegetable are is covered with polyethene bag. Water is then released through the PVC to wet the sand in the cavity. Bamboo are cut and thatched made from it and straw it will measure (1.65m x 1.15m). The bamboo thatched is then used to cover the chamber.

#### Erection of Shade

Soil is dug in six places for the shade. This is then filled with cement and sand mixture. The bamboos are then put into the hole and allow to solidify. This is allowed to stay for two days. Other bamboo nodes are put on top and straws are matted on top.

### 6. CONCLUSION

The outcome will be a cooling chamber with a shelter over it. The shelter is meant to protect the chamber from rain and direct sunlight. This chamber is expected to increase the shelf life of the fruits and vegetables stored in the chamber.

#### Work plan/Time Frame

S/N	Program	Duration
1.	Brick moulding	One Month
2.	Land preparation and Foundation laying	Two weeks
3.	Bamboo collection	One week
4.	Training	One Month
5.	Building of shade	One Month
6.	Publishing And Dissemination	One Month

Duration of Research Work: Six (6) months

#### Budget:

DESCRIPTION	QTY/NO.	UNIT COST	AMOUNT(₦)
<b>Consumables</b>			
Brick	200	300	60,000
Sand	1 trip	25,000	25,000
Bamboo	30	400	12,000
Saw	1	5000	5,000
Nail	2kg	2,000	2,000
PVC	2	20,000	20,000
		<b>Sub-Total</b>	<b>124,000</b>
<b>Equipment</b>			
Rake	1	5,000	5,000
Shovel	1	5,000	5,000
Straw		15,000	15,000
Water tank	1	90,000	90,000
Cement	2	5,000	10,000



Polyethene	1	2,000	2,000
Jute Bag	2	2,000	4,000
Plastic crate	10	4,000	40,000
		<b>Sub-Total</b>	<b>171,000</b>
<b>TRANSPORTATION AND WORKMANSHIP</b>			
Transportation of bamboo			20,000
Transportation of sand			30,000
Transportation to Lagos			40,000
Bamboo thatched weaving			20,000
Construction of shelter			80,000
Logistics			40,000
		<b>Sub-Total</b>	<b>230,000</b>
Remuneration for co-researcher 1 persons (6 months)		<b>Sub-Total</b>	<b>250,000</b>
<b>Dissemination</b>			
Publication (International Journal)			120,000
Extension and Training			250,000
		<b>Sub-Total</b>	<b>370,000</b>
		<b>Grand Total</b>	<b>1,145,000</b>

## 7. REFERENCES

- [1] Abimbola O.A., (2014). Post-harvest Losses and Welfare of Tomato Farmers in Ogbomosho, Osun State, Nigeria. Journal of Stores Products and Post-harvest. Vol. 5(2) . Pp. 8-13, June 2014.
- [2] Adesida; M. A. (2009): Market Driven Research Projects Delivered at the 2009 In House Review Meeting NSPRI Headquarters. Ilorin. Nigeria.
- [3] Adekalu, O. A. (2014). Studies on the Physico Chemical, Handling and Storage of sweet Oranges. (Citrus sinensis Osberk) PhD Thesis submitted to Federal University of Agriculture Abeokuta, Nigeria.
- [4] Adekalu; O.A. (2014): Post harvest losses of Tomatoes (L. esculentum) Stored in Natural Preservatives. Asian Journal of Agriculture and Food science 2 (1):420-424.
- [5] Alazar, A. (2007). Horticultural Marketing in Ethiopia. M.Sc. Thesis. Haramaya University, Haramaya.
- [6] Atanda S. A., P. O. Pessu, S. Agoda, I.U. Isong and I. Ikotun (2011).The Concepts and Problems of Post-harvest Food Losses in Perishable Crops. African Journal of Food Science Vol. 5 (11) pp. 603-613, 15 October, 2011.
- [7] Babalola D.A., et al.(2010). Determinants of Post-harvest Losses in Tomato Production: A case study of Imeko-Afon Local Government Area of Ogun state, Nigeria. Global Journal of Science Frontier Research 3.2 (2010): 14-18.
- [8] Chris B.W., F.N. Jacqueline (2012). Production Guide for Storage of Organic Fruits and Vegetables, Department of Horticulture, Cornell University, NYS IPM Publication No. 2012, 10.
- [9] FAO, (2008). Food and Agriculture Organization. The World Vegetable Center News Letter (www. Avrdic. Org. visited 2012/2013).
- [10] FAO (2010). Global Food Losses and Food Waste. Food and Agricultural Organisation of the United Nations.Rome 2011.
- [11] FAO (2010) Global Hunger Declining but Unacceptably high: International Hunger Target Difficult to Reach. Economic and Socila Development Department. September 2010 Rome
- [12] Gudilla A. K., L. M. Hadijah; A. Mbwanda, R. J. Mongi and C.C. Ruheme (2013). Assessment of Post harvest Handling Practices, Knowledge and Losses Fruits in Bagamoyo District of Tanzania. Food science and Quality Management Journal Vol 11 www.iiste.org. Online.

- [13] IARC.(2003).Fruits and Vegetables. International Agency for Research on Cancer (IARC) Working Group on the Evaluation of Cancer Prevention Strategies. (2003): 2.
- [14] Ibeawuchi, I.I., O.J. Chiedozi, O.M. Onome, I.E. Ememnganha, N.F. Okwudili, N.V. Ikechukwu, and E.I. Obioh (2015). Constraints of Resource Poor Farmers and Causes of Low Crop Productivity in a Changing Environment. *Researcher* 2.8 (2015): 68-72.
- [15] Idah, P.A., E.S. Ajisegiri and M.O. Yisa, (2007). Fruits and vegetables handling and transportation in Nigeria. *African Union Journal* 10.3 (2007): 175-183.
- [16] Kitinoja L. and M.Cantwell (2010). Identification of Appropriate Post-Harvest Technologies for Improving Market Access and Incomes For Small Horticultural Farmers In Sub-Saharan Africa And South Asia". WFO Grant Final Report to the Bill and Melinda Gates Foundation (2010).
- [17] Kitinoja L and H.Y. Al Hassan. Identification of Appropriate Post-Harvest Technologies for Small Scale Horticultural Farmers and Marketers In Sub-Saharan Africa and South Asia-Part 1: Postharvest Losses and Quality Assessments". *Acta Hort* 934 (2012): 31-40.
- [18] LeBlanc D.I. and K.P. Hui. (2005). Land transportation of fresh fruits and vegetables: An update. *Stewart Post-harvest Review*, pp. 1.4.1–1.4.13. ISSN 1745-9656.
- [19] Meena H.S., K.M. Singh, and H.R. Meena (2009). Farmers's Attitude towards Post Harvest Issues of Horticultural Crops. *Indian Research Journal Ext. Edu.* 9(3). September 2009.
- [20] Mohammed K, and B. Aferwork, (2018). Post-harvest Loss and Quality Deterioration of Horticultural crops in Dire Dawa region Ethiopia. *Journal of the Saudi Society of Agricultural Science*. Vol 17:88-96.
- [21] Mrema, C.G. and S.R. Rolle (2002). Status of the Postharvest Sector and its Contribution to Agricultural Development and Economic Growth. In: 9th JIRCAS International Symposium – Value Addition to Agricultural Product, pp. 13–20.
- [22] Nasrin T.A., M.M. Molla M. A. Hossain, M. S. Alam and L. Yasmin.(2008) "Effects of post-harvest treatments on shelf life and quality of tomato. *Bangladesh Journal of Agricultural Research* 33.3 (2008): 579-585.
- [23] Nath A., L.R. Meena, K. Vinod and A.S. Panwar (2018). Postharvest Management of Horticultural Crops for Doubling Farmer's Income. *Journal of Pharmacognosy and Phytochemistry* 2018; SP1: 2682-2690.
- [24] Olayemi, F.F., J.A. Adegbola, E.I. Bamishaiye, A.M. Daura (2010). Assessment of Post-Harvest Challenges of Small Scale Farm Holders of Tomatoes, Bell and Hot Pepper in some Local Government Areas of Kano State, Nigeria. *Bayero J. Pure Appl. Sci.* 3, 39–42.
- [25] Omosomi O. (2017). Tomato consumer survey. <https://tomatoconsumersurvey>. Retrieved August 2017
- [26] Saraswathy S, Preethi TL, Balasubramanyan S, Suresh J, Revathy N and Natarajan S.(2010).Postharvest Management of Horticultural Crops. Agrobios, India.
- [27] William T.K. (2020). BotanicalGarden. <https://www.missouribotanicalgarden.org/Portals/0/Gardening/Gardening%20Help/Factsheets/Storage%20of%20Fruits%20and%20Vegetables43.pdf> Retrieved: August, 2020.