FEDERAL UNIVERSITY OF TECHNOLOGY MINNA

THE END OF CROP STORAGE IS THE BEGINNING OF NEW PRODUCTS

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B. Sc., M. Sc. (Alabama, USA), PhD (Bedford, UK)
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INAUGURAL LECTURE SERIES 70

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1.0 Introduction

Storage of agricultural produce after harvest is as old as agriculture itself. Crops are usually gathered and kept for future use. The process may be diverse and the length of time may be long or short. Normally, harvested crops cannot be consumed all at the same time and seeds need to be preserved for the next planting season. There is, therefore, the need to store produce in such a way that its quality dose not deteriorate.

In ancient history, harvested crops were preserved as an insurance against famine. The celebrated case in the Bible was when Joseph was asked to buy grains for seven years (Gen 41) against seven years of famine that was coming. Overtime, farmers have learnt different techniques for storing their crops. In the past, storage techniques were devoid of chemical additives unlike now.

It is essential that crops to be stored for future use either for consumption or planting must be cared for right from the farm. Several pest and disease organisms cross over from pre-harvest to post-harvest stage. A well-known example is the infestation of cowpea the presence of Callosobruchus maculatus (the common bean weevils), beginning from the farm into the storage room. Critical also is the damage incurred by crops during harvest especially fruits, tubers and vegetables. Bruises or defects during harvest could enlarge during storage.

The topic of this Inaugural lecture was chosen because many people have thought that where crop storage ends is the end of that year but my perceptive is to see crop storage as "**The end of crop storage is the beginning of new products.**" The Inaugural lecture is to look at crop storage as the coming out with new things/products that can help people to stay alive.

If crop produce is to be stored, it is important to begin with a high quality product. Each lot of produce must not contain damaged or diseased units, and containers must be well ventilated and strong enough to withstand stacking. In general, proper storage practices include temperature control, relative humidity control, air circulation and maintenance of space between containers for adequate ventilation, and avoiding incompatible product mixes.

1.1 Reasons why farmers store agricultural products

Mr. Chairman Sir and distinguished audience this Inaugural lecture will discuss how agricultural products are harvested and stored by farmers. In most cases, the products are stored without further handling for shorter or longer periods. Unfortunately, losses of 25 percent for stored grain crops and 40-50 percent for vegetables are not unusual in the tropics. For the farmers, stored products fulfil various needs:

Food for the family

It is important to have enough food; but to stay healthy, it is also important to have food that is of good quality. Farmers and their families can clearly see whether they will run out of grain to eat before the next harvest, but loss of food quality is more difficult to measure. Some insects eat the best parts of the grain, which contain the vitamins and minerals that make the food nutritious. Farmers may not see this loss and therefore need to know how to prevent it.

Income

Farmers have to buy or barter for things they need but do not produce themselves. Most farmers sell the products they do not use for food or planting material to earn money, or they trade their own products for the things they need. If farmers have only drying and storage facilities, they cannot keep their products safely for long and are forced to sell the products soon after harvest. The prices are low at this time because no one needs grain. Everyone is harvesting and there is plenty of grain available. If the farmers can dry and store the products safely, they may be encouraged to grow more than they need for their families. Good grain storage can thus lead to more food, more money, better planting material, and a better standard of living for farmers and their families.

Seeds for next planting season

Part of the harvest is used as propagation material for the next cropping season. If seeds or tubers are not stored well, some will not germinate (grow) when planted, which means the farmer will have to plant many more to get enough plants. The seedlings may also not grow at the same speed which will cause problems for the farmers during weeding and harvesting.

With this, I wish to encourage small-scale farmers to improve their storage methods for grains, roots and tubers, fruits and vegetables.

2.0 How to retain the quality of stored agricultural products

2.1 The product to be stored determines its shelf life

Agricultural products cannot be stored indefinitely. The maximum storage duration (the shelf life) of agricultural products varies and can be only a few days for some fruits and vegetables, a

couple of months for most tubers and bulbs, and over a year for dried food grains or other seeds (Figure 1).

The shelf life of some fresh agricultural products can be extended by cooling, but this is expensive (Raghavan *et al.*, 2005; Vigneault, 2005). For all crops, the most important thing is that they remain edible during storage. Most food grains, fruits and vegetables should also keep their attractive appearance. A wrong colour, wrinkles, etc., make them less attractive to consumers.

For each product, numerous factors pose a threat to their shelf life. These threats are present not only during storage, but during the whole pipeline of food production to consumption or marketing (see Figure 2). Each step can have an impact on the quality and quantity of the products.

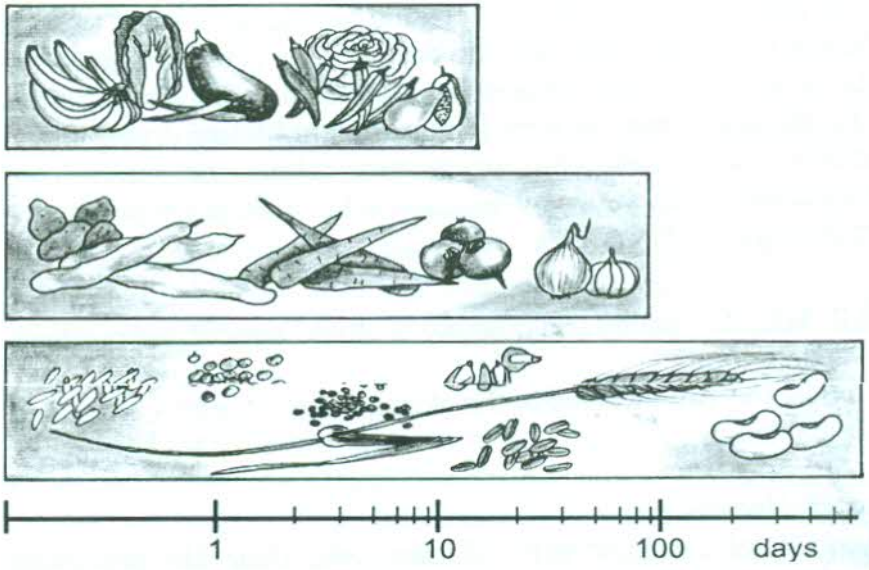


Figure 1: The shelf life of agricultural products depends, on the product itself

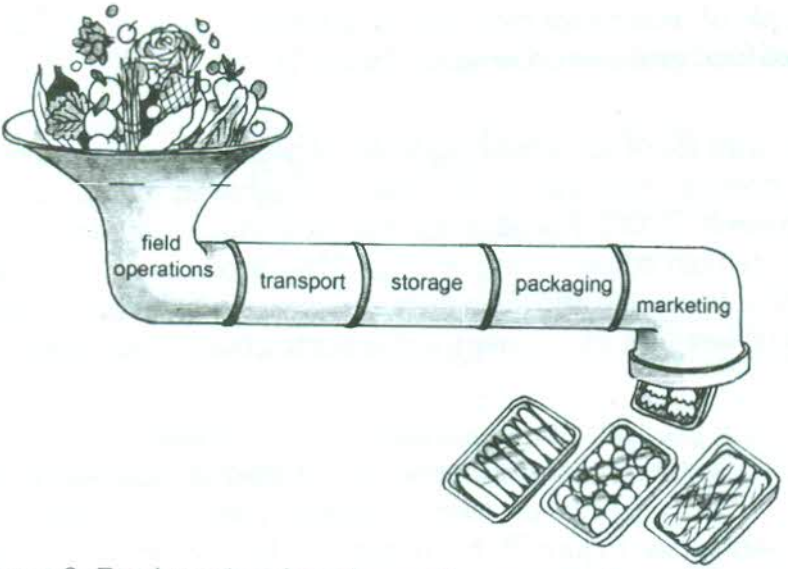


Figure 2: Food pipeline from harvest to consumption

If proper storage is not possible and a product is likely to spoil before it can be consumed, the best solution is often to preserve it. Preservation means modifying a product so that its properties change and it can be kept longer. Examples are drying fruits, making flour from yam or cassava tubers, or mash from tomatoes. In this way, new products with different properties are made that are still edible.

2.2 Why the quality and quantity of stored agricultural products deteriorate

Two factors are involved in the storage of food grains, fruits and vegetables:

Internal factors

Agricultural products are still alive and their life processes continue after the harvest. All products respire (breathe). They use oxygen from the air to burn their reserves. The products thus

become thinner, and they produce carbon dioxide and heat. Another continuing process is ripening. Fruits often change colour as they ripen, and their tissue gradually becomes softer (Adeniyi and Ayandiji, 2014). Eventually, the fruit becomes overripe and is then unsuitable for consumption. Fruits and vegetables, and to a slightly lesser degree tubers, tend to lose water as they get older in storage.

The product becomes wrinkled and is less attractive to consumers. Respiration, ripening and water loss are internal factors that determine the quality of stored products (Tsado. 2015; Tsado *et. al.*, 2018)

External factors

External factors, which also play an important role in the loss of product quality and quantity, include:

Mechanical Injury

Seeds, roots and tubers are easily injured during harvest. Fresh fruits and vegetables are particularly susceptible to cuts and bruises owing to their tender texture and high moisture content. Poor handling, unsuitable packaging and improper packing during transportation are the causes of bruising (LeBlanc and Hui, 2005; Leblanc and Vigneault, 2006), cutting, breaking, impact wounding, and other forms of injury in fresh fruits and vegetables.

Microbial Load: Fungi and Bacteria

After harvesting, the natural defence mechanisms of agricultural products rapidly decline. Bacteria and fungi then easily infect roots, tubers, fruits and vegetables. Most fungi have threadlike structures. These are also called moulds. Bacteria and fungi cause rotting of the products, if the products are wet enough to support

the growth of these micro-organisms (Tsado and Aghotor, 2012; Mattoo *et. al.*, 1975). Seeds are generally less vulnerable if they are stored under dry conditions.

Insects, rodents and other animals
All these pests like to eat seeds and other stored agricultural products and can thus be the cause of large losses (Asante *et. al.*, 2007).

2.3 Factors which influence fresh produce quality

A number of factors influence fresh produce quality:

Temperature Conditions: Plants require precise temperature conditions in order to flourish. For crops/fruits (rice, yam, sweet potatoes, oranges, grapefruits, and pineapples), temperatures during the day should vary between 23 and 30°C. However, when conditions are too warm, the fruits and vegetables lack the characteristic aroma and flavour desired by consumers.

Metabolic Stress or Natural Senescence: Metabolic stress is brought about exposing crops, fruits and vegetables to high or low temperatures. Metabolic stress has a negative impact on quality, and often renders fruits and vegetables unsaleable. Tropical fruits such as mangoes, citrus and most vegetables are damaged if stored below 8°C, due to chilling injury. Natural senescence also causes loss in quality. Age after harvest will reduce the attractiveness of colour and leads to softening and rotting.

Transpiration and Water Loss: Water loss reduces the freshness of produce. Produce displayed in supermarkets often decline in quality, owing to prolonged exposure to dry air (Alvo *et. al.*, 2004).

Mechanical Injury: Mechanical injury leads to bruising in fresh produce and can occur during harvest, transportation or display at the supermarkets (Kra and Bani, 1988).

Microbial Infection: Micro-organisms such as fungi are the cause of fruit rots and thus render fruits and vegetables unsaleable (Tatsumi *et. al.*, 2006).

Cardboard Packaging: Cardboard packaging can cause quality loss in fresh produce, owing to the development of musty flavour (Idah *et. al.*, 2007)

2.4 Prevention of storage losses

In general, prevention is usually focused on controlling the different internal and external factors that are responsible for loss of quality or quantity of the products.

Senescence/over-ripening, respiration and loss of water all make products deteriorate. These processes can be slowed down by chilling the products. Tubers, with the exception of cassava, can be kept in a state of dormancy, and as long as this state is maintained, they will remain fresh and will not be wrinkled. Loss of water in roots and tubers can be prevented by storing them in a humid environment, for instance in wet soil (example of sweet potatoes). On the other hand, seeds are best stored in a dry environment because life processes including respiration are then slowed down (FAO, UNEP, 1981).

Harvesting when still unripe can be a good option for prolonging the shelf life of some fruits and vegetables. Mechanical injury has to be prevented before or during the harvest, for instance by carefully threshing seeds or using protective packaging during transport of powders, fruits and vegetables. Sometimes, special

varieties of a crop are available that are less susceptible to injury, like 'Roma' tomato. Some rotting of fruits, vegetables, roots and tubers by fungi or bacteria can be prevented by keeping the crops healthy during the growing season (Kader, 2002).

Rotting of the produces by these same micro-organisms in storage, can be prevented or delayed the aging of the products. Deterioration of seeds due to micro-organisms can also be prevented by drying the seeds.

Insects and rodents need to be prevented from contaminating the crop before harvest, and also prevented from entering the storage facility.

2.5 Storage principles

Most agricultural products are not consumed immediately after harvest but have to be kept in storage for some time (Babalola *et. al.*, 2010; Akangbe, *et. al.*, 2014; Adeniyi and Ayandiji, 2014). The challenge in storing agricultural products is to prevent them from deteriorating and losing quality. The following points are considered:

1. Sometimes not picking or harvesting products until they can be consumed is an option for tuber and bulb crops and for some vegetables and fruits. Most products, however, need to be harvested right away at maturity, to prevent their quality from decreasing too much and to reduce the chances of attack by pests and diseases or theft.

2. Leaving the products in the field after harvesting is possible and desirable in some cases, but it is always risky because the conditions of weather and presence of pests and diseases are

uncontrollable (Bachmann and Earles 2010). For some products, this would even be disastrous, because exposure to direct (tropical) sunlight would ruin them. This is particularly true for sowing seeds that cannot tolerate temperatures above 40-45°C, and for vegetables and fruits.

3. For tubers and bulbs, it may be beneficial to leave them for some time (not too long) in the field at high temperatures (Naziri, *et. al.*, 2014; GTZ. 1999). Seeds need to be dry for safe storage. So in periods of dry weather, drying could very well be done in the field.

4. During transportation and storage, some products are easily bruised or injured. This must be prevented by careful harvesting, but also by ensuring proper packaging and careful driving of the transport vehicle (Vigneault, *et. al,*. 2009; Vigneault, 2005; Idah, *et. al.*, 2007).

5. If seeds cannot be dried in the field, they have to be dried inside a building. If the weather is mostly dry, they can be dried in a well-ventilated building. Once dry, they can be kept in this ventilated building or packaged and stored elsewhere. If the weather is mostly humid, they have to be dried artificially by using a fan and a current of warm air. The temperature should not become too high because the seeds may then die.

6. The products are stored until consumed by the family or until they are transported to the market(s). The optimal conditions may vary with product.

i. In all cases, temperature is important. Generally, the lower the temperature, the longer the storability. Refrigeration is

suitable for some products, but for economic reasons, it is mostly used only with expensive products that come in small volumes (Wang, *et. al.*, 2009). Some tropical fruits are injured by low temperatures.

ii. Products that respire should not be stored airtight, so not in plastic, closed containers or warehouses without ventilation.

iii. Products that do not breathe (dry seeds) can be stored in airtight containers or spaces.

iv. Products that contain a lot of moisture must be stored in relatively humid conditions. These conditions are also favourable for the growth of fungi and bacteria, so care should be taken to store only products that are free from fungi and bacteria. Seeds that are still too wet to be stored under airtight conditions need to be stored in spaces with only very small holes to keep insects, rats and mice out, but on the other hand also need good ventilation to further the drying process.

v. Fruits and vegetables that produce ethylene gas during ripening cannot be stored together with many other fruits and vegetables, because ethylene gas causes over maturing (Mahmood, *et. al.*, 2013).

vi. Regular (daily) inspection is important to detect product deterioration and attack by rodents and insects as early as possible.

If the volume of product harvested is greater than that needed for family consumption, part of the products could also be preserved to increase its shelf life (Tsado, *et. al.*, 2015).

3.0 MY CONTRIBUTIONS

3.1 Storage

Storage life is governed by several factors including crop variety; stage of maturity; rate of cooling; storage temperature; relative humidity; rate of accumulation of CO_2; pre-packing and air-distribution systems.

Optimum refrigerated storage requirements for different fruits and vegetables are as follows: 1.7–3.0°C for apple; 12.8°C for banana; 0–1.7°C for grapes; 8.3–10°C for guava; 8.3–10°C for mango; 5.5–7.2°C for orange and 8.3–10°C for pineapple.

3.2 Edible Coatings

Composite coating of polysaccharides (cellulose, pectin, starch, alginate, and chitosan), proteins (casein, soy) and lipids (waxes, mineral oils) have been extensively used in controlling spoilage of fruits and vegetables (Baldwin et al., 1995; Lin, and Zhao, 2007: Tsado, *et al.*, 2018; Tsado. 2012).

Waxes prevent moisture loss during fruit storage. Although natural waxes on fruits are effective in preventing water loss, the application of commercial wax can further decrease water loss during prolonged storage. Some local waxes and oils being tried especially in our present environments are shea butter oils and coconut oils is an example of such oils and waxes (Tsado 2012; Tsado and Aghotor, 2012). Shea butter is a vegetable fat obtained from the kernel of the products of the Shea tree (*Vitellaria paradoxa*), a tree having a place with the group of Sapotaceae. The tree is indigenous oil delivering wild plant openly developing in Africa (Honfo, *et al.*, 2012; Masters *et al.*, 2004).

Reason why waxing is more efficient than most other methods of preservation, is that introduced into the fruits for desirable effects such as maintenance of firmness. Waxes present moisture loss during fruit storage. Reason why waxing is more efficient than any other method of preservation, is that permeability is a major problem when water soluble materials such as calcium need to be introduced into the fruits for desirable effects such as maintenance of firmness (Lin and Zhao, 2007; Tsado, 2012). Waxes present moisture loss during fruit storage. Although natural waxes on fruits are effective in preventing water loss, the application of commercial wax can further decrease water loss during prolonged storage.

3.3 Value Addition

In recent years, the processing sector has seen things like adding value to some stored crops/fruits and vegetables (rice, yam, sweet potatoes, Irish potatoes, oranges, grapefruits, groundnuts and pineapples), converting them into produce that could be stored better than what they used to be (Sayre, *et al.* 2011; Maikasuwa, and Ala, 2013). New products of commercial value include candies with a sugar content of lower than 78%, dried chips with a moisture content of 8%, squash with 25% juice and 40°Brix, lime blended squash in the ratio of 1:1 having 25% juice with 45°Brix were most acceptable. Custard apple, papaya, passion fruit, pomegranate, muskmelon, watermelon products were developed and commercialized (Van Loo-Bouwman, *et al.*, 2014; Akinnifesi, *et al.*, 2008).

3.3.1 Minimal Processing: Minimally processed products are convenient ready to be used or ready to eat fruits and vegetables with fresh-like quality and containing natural ingredients (Anwar *et. al.*, 2008). Fruits such as pomegranates and vegetables such as carrots, beans, cabbage, okra and tomato are cut, diced or

shredded to uniform size for commercial markets (Tsado, 2015; Tsado, *et. al.*, 2015).

Maize (*Zea mays*), Yam tubers (*Dioscorea rotundata Poir*) and Cassava tubers (*Manihot esculentus*) are processed into flours to be used as foods, animal feeds or stored out as dried flours (Otitolaiye and Tsado, 1999; FAO 1998; Gana, *et. al.*, 2010; Tsado, 2015).

Plate 1. The international threshold for emergency response, nutritious vitamin A orange maize gains ground on the national market (Tsado, 2015).

3.3.2 Marketing: The infrastructural facilities of existing wholesale and retail markets are inadequate for improving the marketing and safety of crops, fruits and vegetables. Heaps of wasted fruits and vegetables can be found near open markets.

Highest losses occur at the retailer point, since damage is cumulative. With the exception of a few supermarkets and organized vegetable outlets, fruits and vegetables are exposed to sunlight and polluted environments when displayed for sale.

Plate 2: Sorted damaged orange fruits on a refuse dump arising from transportation and packaging (Oyeniran, 1988).

Fruit ripening chemicals are commonly used for the artificial ripening of fruits in Nigeria. Calcium carbide is widely used for the ripening of mangoes, papayas and bananas in several Nigerian markets. Acetylene is not harmful if properly used. The dosage used by traders normally exceeds the level of 1g/kg of fruit, which is recommended by the Federal of Agriculture. The method used in the application of carbide is also hazardous to health in that carbide pieces can find themselves among the

heaps of fruits. Excessive use of commercial grade calcium carbide results in direct contact with the fruits causing contamination with carcinogenic compounds such as arsenic and phosphorus hydrides. 'Ethrel' is a harmless ripening-induced chemical which releases ethylene. Ethrel® 480 SL is a soluble liquid concentrate containing 480g. a.i./l Ethephon It is used in large cities in Nigeria.

This compound, which is recommended by the Nigerian Federal of Agriculture, is slowly gaining popularity among fruit collectors and traders for ripening bananas, mangoes and some other fruits like avocados and papaya (Singh and Janes, 2001).

Plate 3. "Ethrel' is a harmless ripening-induced chemical used by fruit collectors and traders of mangoes

3.4 Issues and Impediments to Improving Marketing and Safety

Issues and impediments associated with the improvement of marketing and safety of crops fruits and vegetables are socio-

economic and technical in nature. Urbanization also influences all aspects of food production and consumption.

3.4.1 Pre-harvest Practices: Farmers often practice improper pre-harvest practices such as the use of poor quality planting material, the application of excessive quantities of pesticides, use of pesticides not recommended by authorized institutions and which do not adhere to the pre-harvest interval requirement prescribed by the Department of Agriculture. These factors adversely affect the quality and safety of agricultural commodities/produce - crops, fruits and vegetables (Osunde, 2008).

3.4.2 Varieties and Cultivars: Lack of suitable varieties, which allow the locally produced crops, fruits and vegetables to compete in local and international markets, and for the manufacture of value added products are another constraint to improving the marketing of crops, fruits and vegetables. Tomato varieties grown in Nigeria are not very suitable for manufacturing value added products such as tomato sauces. Leading manufacturers in Nigeria therefore import considerable quantities of tomatoes on an annual basis for the production of tomato-based products for the local markets.

3.4.3 Seasonality of Crops: Most crops, especially yam, fruits and vegetables are seasonally produced. Excessive production during the peak harvesting season results in a slump in prices to unprecedented levels owing to market gluts. On the other hand, during the off-season, when production is low, prices automatically increase. This situation drastically affects the efficiency of the marketing system especially in the export market due to price fluctuation and non-uniformity of supply of the crops, fruits and vegetables throughout the year.

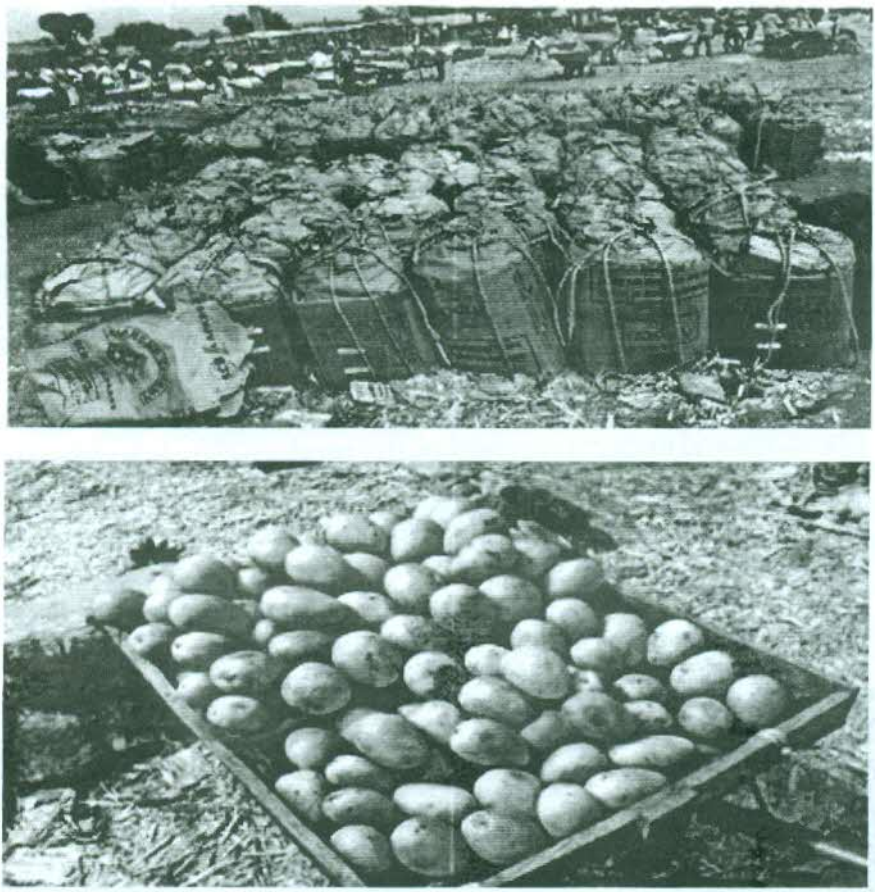


Plate 4: Quality of fruits transported to many markets (arising from improper handing and transportation) in Minna, Niger State (Tsado, et, al., 2015).

3.4.4 Availability of Capital: Poverty within the farming community and lack of capital for the acquisition of improved technologies by producers, collectors, wholesale and retail traders is apparently the major constraint to improving the marketing and safety of agricultural commodities. Fresh crops, fruits and vegetables are packed primarily in baskets, poly-sacks

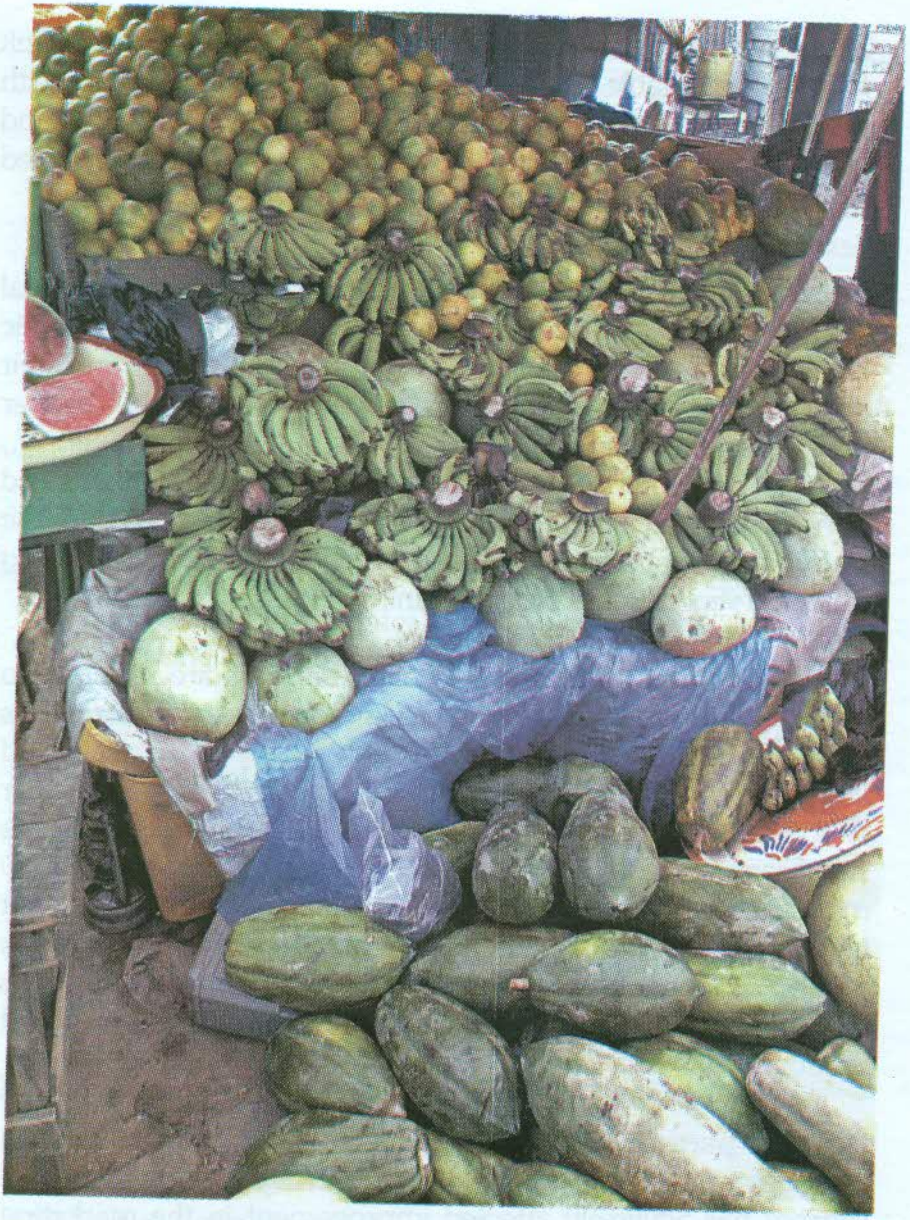


Plate 6: How fruits and vegetables are displaced in most markets, in Niger State (Tsado, *et, al.*, 2015)

post-production sector, here is an urgent need to strengthen the extension arms of existing public and private institutions by making use of modern communication technologies so that data and information pertaining to appropriate technologies and required standards such as HACCP, GAP, etc., reach the large number of people involved in the existing marketing chains in an effective manner (Tuner, 2005).

4.0 National concerns and problems in reducing Postharvest losses and some recommended corrective measures

Reducing postharvest losses is one of the key measures to achieving food security and poverty alleviation. The national significance of reducing postharvest losses is highlighted by loss reduction programs being developed and implemented by the Nigerian Government Attainment of the national goal of reducing postharvest losses is, however, constrained by a number of issues and problems:

4.4.1 Concern #1

Support for the improvement of postharvest research and development is limited, and not sustained. Given the science-based nature of postharvest technologies, support from both the private sector and government is required for its development. The private sector lacks commitment or sometimes does not want to provide counterpart support for the development of postharvest technologies and improvement of postharvest handling systems.

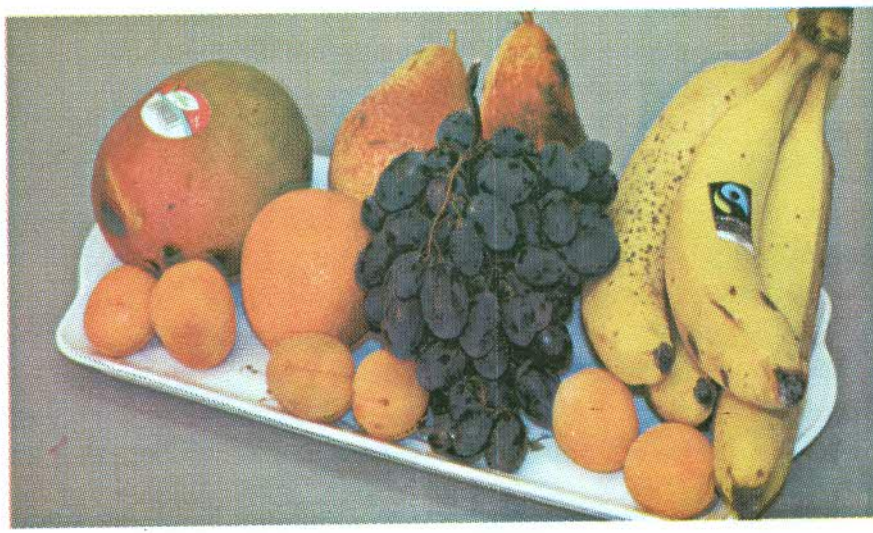
Recommended Measure: Government support is required to strengthen the capacity of institutions to undertake research in the area of postharvest. At the same time, private sector should support postharvest research and development. Within this

context, governments should promote and encourage private investment in postharvest research and development which complements public investments for enhancing productivity.

4.4.2 Concern #2

The use of Calcium carbide for ripening of fruits has become a problem in Nigeria. Most of our fruits (particularly banana) are now ripened with the use of chemicals that are prone to cancer in the individual or consumers.

Recommended Measure: Governments should discourage the use of Calcium carbide and Acetylene in the ripening of the products. A law should be promulgated to discourage farmers from its use.



4.4.3 Concern #3

The production-distribution continuum in the Nigerian government is disjointed or fragmented owing to the geographical nature of the country. Supply chains for perishable

crops are consequently fragmented and losses and distribution costs are high (Ugwuona and Suwaba 2013). The existing distribution system is inefficient due to lack of functional postharvest facilities, poor infrastructure and a weak policy environment.

Recommended Measure: Governments should support and strengthen the capacity of cooperatives and encourage cooperative marketing of those crops that are produced on small farms (bananas, mangoes and pineapples). Cooperative arrangements would facilitate production scheduling, meeting volume and quality requirements and direct marketing, with fewer intermediaries in the supply chain. Governmental support is also required for the improvement of infrastructure such as farm to market roads, cold chain systems, trading/collection centres and postharvest facilities such as packing houses and storage facilities so as to enhance efficiency in the distribution system thereby assuring consistency of fresh produce supplies to larger areas of the country.

4.4.4 Concern #4

Quality standards developed for all crops and fresh fruits are used on a voluntary basis (Katarzyna, *et. al.*, 2008).

Recommended Measure: Through the Ministries of Agriculture, Livestock and Fishery Product Standards, a scheme or system of product standard enforcement, accreditation and inspection should be implemented.

4.4.5 Concern #5

Marketing support systems in terms of price information are weak, unreliable or are totally lacking. Price information is

important to producers in formulating marketing strategies in order to maximize the returns from their produce. Whether the product should be stored or not or should be transported to distant markets to take advantage of a higher price would be influenced by the market price of the products.

Recommended Measure: A National Marketing Assistance Program should be established by Government. This Program should focus on providing timely and reliable market information to producers. I suggest the return of the "Marketing Boards."

5.0 Conclusion

Expansion influences all aspects of food production and consumption. Growth usually involves varying degrees of modernization and westernization, which may influence dietary habits and consumption patterns. A shift away from starchy roots and coarse grains to wheat and rice is a common and irreversible trend associated with urbanization of populations that traditionally consumed the former staples.

The predominance of rice, followed by wheat (bread), in the Nigerian urban sector is obvious, whereas in rural areas consumption of wheat is almost negligible and the diet is dominated by maize, millet, sorghum and yam products. There has been an urban swing away from the consumption of traditional starchy staples such as yam and cassava, towards processed and convenience products such as eba (gari) dish of cassava couscous, and plantains, often sold in cities as a snack food of fried plantain chips.

A major reason for the shift away from traditional staple foods is convenience. For example, white rice cooks easily and quickly, and wheat products, particularly bread, offer important

advantages to consumers who have to travel to work on public transport and usually eat their midday meal away from home, in the form of snack foods or sandwiches.

Recommendations

Food industries are a relatively new commercial area in Africa. Their development has been based in part on concepts of added value, fostering processing of primary commodities that are traded internationally such as tea, coffee and cocoa, and of import substitution, fostering production of fruit juices, soft drinks and beer. They contribute to the much greater availability of basic processed food items (e.g. milled flour and vegetable oil) for local purchase and sale, and they help to reduce women's workload. Small-scale, community-based food processing plants are as important as large-scale food industries in preserving food quality, preventing

1. These companies produce a variety of consumer goods ranging from breakfast cereals to instant coffee, dried milk powder, weaning foods, sauces and pickles. Thus the range and choice of food commodities tend to be wider in the urban areas. However, many of these commercial products tend to be priced beyond the means of the urban poor, who are dependent on urban and per-urban markets for most of their food requirements.

2. The purchased food is supplemented by the little food they can grow in the limited space available, by gifts from visiting rural relatives or by any food they can acquire during visits once or twice a year to their home village.

3. More market research is no doubt needed for food technology development, with particular reference to urban consumers' perceptions, attitudes, preferences, wants, means and behaviors regarding food. Such research could lead to the

commercial development of convenient versions of some traditional foods or dishes, which might stimulate the consumption of local foods by urban consumers. Development of such products can strengthen rural/ urban economic links by enhancing demand for the production of traditional foods in rural areas and by reducing urban dependence on food imports of cereals such as wheat and rice.

4. One of the most universal locations for street food vendors is outside the gates of urban schools and colleges. Not only is there a sizeable demand for street foods among children, in some countries this food comprises an important part of the students' daily diet.

5. This sector (street foods) provides a valuable service for urban consumers and a source of cash income for vendors, many of whom are women. However, it also spreads various socio-cultural changes in food habits, introducing behaviors such as eating alone, snacking and replacing meals by "fast food". In addition, problems of hygiene and food safety are bound to arise under the unsanitary conditions of the slums where the poorest groups live.

6. National research organizations, which include universities, research institutes and the national agricultural research centers, have made tremendous achievements in agricultural research and added substantially to some of the successes that have contributed to increased and more diversified food production.

7. Currently, most national agricultural research systems face many financial and operational problems. Those scientists who choose to stay are often not fully utilized for lack of adequate

funding and are usually not well motivated to produce much, even if there is a possibility to do so.

8. Another long-standing problem has to do with the dissemination of research findings. Few countries have formalized links between researchers, extension workers and farmers. This situation is cause for worry and needs to be addressed immediately.

9. National research organizations have a mandate to focus their research activities within the national agricultural research agenda. They should also establish and strengthen links with local farmers and extension systems, consumer groups and the private sector within the country in order to foster more effective communication and to devise ways of managing available resources both maximally and efficiently.

10. The most effective way of passing on the knowledge engendered by research to farmers is by involving farmers as partners in the whole research process from the start, including the setting of research priorities and appropriate institutional arrangements, to ensure that farmers continue to be heard. Close interaction with farmers can also give research scientists an opportunity to gain useful knowledge, for example, regarding viable traditional farming systems and practices.

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Mr. Vice-Chancellor and Chairman of this gathering Sir, I have enjoined myself working with several individuals in my academic progression of this journey. Some of them were not pleasant, while others were very attractive and rewarding. This lecture is one of such very attractive rewards.

To Almighty God

First of all, I am highly grateful to Almighty God who allowed me to see this day. His beauty, protection, mercy and grace have helped me to see this day. I do not have words to thank Him for this gracefulness. I shall only say "To You be all the Glory and Adoration till the end of my life."

To My Teachers

I am very much indebted to my teachers that showed me the way to go. The late Mr. William Gana of Mokwa was the person who first told me "that it is good to be focused" because the end is achievable. Late Mr. Gabriel N. Gana was also one of my founding teachers who taught me to "try to achieve it because the future is bright". Mrs. Comfort Adeleke my Headmistress said "hey Eli Kudu you are going to be great so keep it up, God willing, you will get there". Because of her prayers, today I thank God that her prayers have been answered. I cannot forget my secondary school English teacher Mr. J. S. Ajayi, he was ensuring me that "you spoke good English and if you can keep it up I think you will get to the top".

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The Crop Production Department and School of Agriculture and Agricultural Technology is a splendid place. It is one of the first Schools in the University, and also a pace-setter of the University. The Vice Chancellor and Chairman of this occasion is also from the School of Agriculture. I am very much esteemed for his encouragement.

To my Colleagues at the Niger State College of Agriculture, Mokwa

To all my colleagues at the Niger State College of Agriculture, Mokwa and the Federal University, Dutsin-Ma, Katsina State, I say thank you for your inspiration and love during my stay with you.

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To my Late Brothers, Sisters and Parents

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Seminar and Colloquium Committee

I thank you so much for giving me this time to perform this Inaugural lecture. The Chairman and members of this committee were always there to see this work come to a very successful end. Thank you so very much.

The Audience

I cannot but thank you all for being here to hear my story of "Where Crop Storage ends, is where the impossible new life begins, - that's where God starts." Mr. Chairman and Vice-Chancellor Sir, distinguished Professors, friends, invited guests Ladies and Gentlemen this is where I want to end my story.

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A BRIEF PROFILE OF THE INAUGURAL LECTURER

Eli Kolo Kudu Tsado is a **Professor** of Crop Production in the School of Agriculture and Agricultural Technology. He was born on 4th of November, 1953 at Mokwa, to the family of the late Mr. Daniel Nmazhiko Tsado (nee Baba Sunday) and Mama Victoria Kada Tsado (nee Mama Sunday: Nnakuli) of Doko LGA, in Niger State.

Prof. Tsado attended the United Missionary Primary School in Mokwa (later changed to United Missionary Demonstration Primary School, now Kpege Primary School, Mokwa) from 1959-1966 where in 1966, he sat for the 1st School Leaving Certificate and passed well. In 1967, Prof. Tsado was admitted to Bida Secondary School (later changed to Government College, Bida) where he sat for the West African School Certificate in 1971.

He joined the North-Western State Government Service, Sokoto, 1972 as Agricultural. Assistant (Trainee) and was posted to Farm Centre, Bida. He was selected to attend the Agricultural Assistant course at the School of Agriculture, Samaru (later changed to College of Agriculture, Samaru, A.B.U. Zaria) from 04/1974 to 08/1975. After the training he was posted back to Rabba Irrigation Scheme in Niger State. He was later posted to the Sorghum Farm - at the Mokwa - Kontagora junction, Mokwa, (because Rabba Irrigation Scheme had to be closed down). He was in-charge of the harvesting of the Sorghum plant Farm. This

was where he started to conceive the idea of starting a Sorghum pyramid (similar to the groundnut pyramid found at Kano)

On 05/1977, Professor Tsado got an admission to read Agriculture at the Faculty of Agriculture, Alabama Agricultural and Mechanical University, Normal, Alabama, U.S.A. He graduated with a degree of B. Sc. in Plant Science and an M. Sc. in Soil and Plant Science (specializing in Plant Breeding and Cytogenetics).

He returned to Niger State in 1981 and attended the National Youths Service Corps program from 07/1981 to 07/ 1982. He returned from NYSC to the Niger State Civil Service where he became the Agricultural Liaison Officer in charge of Green Revolution Programme, a place he was until 03/1986, when he joined the Federal University of Technology, Minna, as an Assistant Lecturer, lecturing in Plant Biology at both Pre-degree and Degree Levels.

Professor Tsado was admitted to Silsoe College (later re-named as Cranfield University, Silsoe, Bedford, United Kingdom) for his Ph.D degree 1987-1992. His Ph.D. degree was in Postharvest Physiology of Root Crops. He returned to the Federal University of Technology where he was engaged with students and some faculty staff in the area of statistics.

Prof. Tsado went to the Niger State College of Agriculture, Mokwa from 1999 and returned in 2007. He resumed teaching, research and thesis supervision in his Department of Crop Production at the School of Agriculture and Agricultural

Technology, Federal University of Technology, Minna. He was promoted to full Professor in 2016.

Prof. Eli Tsado is a Chartered Biologist (Member of the Royal Institute of Biology, Institute of Biology, United Kingdom), Member (Agricultural Society of Nigeria), Member (Agricultural Economics Society of Nigeria), Member (Weed Society of Nigeria), Member (Biotechnology Society of Nigeria) and Member (Horticultural Society of Nigeria).

He is happily married to Mrs. Rebecca Kiatswa Tsado, with whom they have been blessed with four children: Jonathan, Justina, Afiniki and Joel.

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