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Review

Post–harvest food losses reduction in maize production in Nigeria

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Maize grains constitute the primary sources of food for mankind and a considerable waste of these valuable foods during pre and post-harvest constitute such a major agricultural bottleneck that the reduction of pre and post-harvest losses is now a common food strategy throughout the world. This study was focused on post-harvest food losses reduction in maize production in Nigeria. The study was aimed at identifying the causes of losses during post-harvest and to suggest ways of preventing the identified causes. Review was made economic importance, varieties, soil and climatic requirement, processing and storage of maize. It also sought solutions to some of the identified problems. It was revealed from the study that the fields where the crops are grown among others were identified as sources of insect infestation of stored maize grains; this result in poor quality and loss in market value of the grains. It was established from the study that susceptibility of the grains to attack by insects is determined by their water activity hence, long-term storage; grain must be dried to safe moisture content. In order to minimize these problems of food losses in maize production, harvesting methods be improved upon as to reduce grain losses due to injury which attract insects. Warehouses should be constructed to specification for effective storage of grains, stored products chemicals manufacturing company should be set up in Nigeria while research work must be encouraged through funding by Government and non governmental organizations.

Key words: Post-harvest, maize grain, food losses, pest, moisture content, storage.

INTRODUCTION

Maize grains and legumes constitute the primary sources of food for mankind and a considerable waste of these valuable foods during pre and post-harvest constitute such a major agricultural bottleneck that the reduction of pre and post-harvest losses is now a common food strategy throughout the world (Agboola, 1981). The majority of studies so far undertaken in the whole field of post-harvest technology have been concerned with grains, grain legumes and other durable products which are stored dry, usually at a moisture contents below around 12 to 14%. In these products, post-harvest deterioration is largely caused by the attack of external agents such as insects, moulds or rodents and does not arise from endogenous factors. The conservative loss estimates for stored grain and similar "dry" produce, as used by as used by FAO (1985 a and b) in developing its Prevention of Food Loss PFL programme, were about 10%, with the perishable crops it has been conservatively estimated from the limited data to be found scattered in the literature, together with what might best be described as anecdotal information that the total loss is of the order of 25%. Even in the USA perishable produce has been described by as "the victim of phenomenally high waste because of incredibly poor handling practices", and "the loss rate as a result of multiple handling…is frightful". It was suggested by, that in tropical Africa and India, losses in perishable foods are around 30%. The problem of adequate food and nutrition for the growing population in developing nations is a major one, with more than one billion people (about a quarter of the world's population) presently known to be underfed or malnourished. A considerable amount of work is been carried out in every

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country on food loss reduction studies in reflection of the general global concern over agricultural wastes declared at the seventh special session of the United Nation General Assembly in 1975 in which every nation was called upon to strive for a 50% reduction in post-harvest losses by 1985 (FAO, 1975). The prices of food stuff especially maize continue to grow astronomically beyond the reach of the common man and maize crops are always found growing luxuriantly during growing period, but it is always soon discovered that much of the crop do not get to the ultimate consumers probably because of the losses they encountered during pre and post-harvest handling. Therefore, pre-harvest losses in maize production are losses encountered in the field by farmers from the point of cultivation of crop to the point of harvest. While losses encountered from the point of harvesting of the crop until it gets to the end users is known as post-harvest losses. Since the Agrarian Revolution with the launching in Nigeria, the Operation Feed the Nation in 1976, food crisis has increased. This is as a result of the interplay of several factors among which is inability to control diseases and pest including storage methods (Aworh, 1999). The National Accelerated Food Production Programme (NAFPP), which started in 1973, was to increase the production of some major food crops such as maize, rice, millet, sorghum etc. The Nigerian Agricultural Insurance Scheme was launched in December 1987 with the aim of reducing risks and uncertainties associated with food losses (Egbule, 2002). The United Nations Environmental Programme (UNED) supports and promotes ecologically sound and sustainable development that will reduce food losses.

ORIGIN OF MAIZE PRODUCTION

Maize (*Zea mays*) alternatively called corn originated from the American Continent where it was cultivated by Indian long before the arrival of Columbus. It is the most important crop grown in the U.S and valued at over four billion dollars annually.

It is the most domesticated of all field crops and all the total maize cultivated in U.S, 88% is harvested as grain, 7% as fodder, 5% as silage while 90% of the grain is fed directly to livestock, 8% milled, 1 ½% goes to production of alcohol about ½% is used for breakfast food primarily corn flakes (FAO, 1975).The European discovery of corn came in 1492 after explorer Christopher Columbus arrived in the Caribbean. Columbus' Son Ferdinand wrote that his father saw a grain "that they call maize and is most tasty, boiled, roasted or ground into flour" Columbus took seed home and by 1500s, Kasther writes, that corn was growing not just in Spain but in Bulgaria and Turkey, slaves carried corn to Africa. The Portuguese-born Spanish explored Ferdinand Magellan's men dropped Mexican seed off in the Philippines and Asia" This corn boom had begun. According to Harlin a corn farmer in the finger Lakes region of New York, in United States gave description of some of the wonders if corn as a work of both art and brilliant mathematics. The Portuguese first introduced maize to West Africa in the sixteen century. It is a crop of world importance (Anyanwu, 1979). However, nearly all the West African maize production is utilize locally in most West-African countries including Nigeria. The world greatest producers of maize are U.S.A, Brazil, the Soviet Union and Mexico.

Economic importance of maize

Maize is a very important crop in Nigeria. It is utilized mainly for human consumption and form about 50 to 70% of the constituents of livestock feed. He maintained that Nigeria produced one (1) million tons of maize in 1975 and an appreciated quantity is imported annually to supplement the local reduction. Maize is a staple food and is sometimes grown on a garden scale where it cannot be grown as a farm crop (Anyanwu, 1979). It is an important source of carbohydrate and if eaten in the matured state, it provides useful quantities of vitamins C. The yellow grain varieties have vitamin A. It is a source of income and maize leaves and stalks contain about 30% of the total nutrients in corn plants; hence it is utilized for pasture. Some maize are cut and fed green to livestock. Maize occupies a central position in having a meaningful, workable and effective food security system in any society.

The dietary importance of maize in the diet of Nigerians cannot be overemphasized; maize, millet, sorghum, rice and other cereals account for about 70% of the total caloric intake in most African countries. The dietary importance of cereals and legumes is increased by the fact that they complement one another. Legumes generally have a high content of lysine, which together with tryptophan tends to be limiting (insufficient) in cereals. On the other hand, cereals are relatively rich in methadone that tends to be limiting in legumes (Aworh, 1999). Consequently, maize and beans provide a better nutrition when eaten together then separately. Maize flour is obtained from processed maize after the removal of the testa by mechanical or local method and it used for dough, pap, bread and biscuit making.

Varieties of maize

Maize varieties are primarily distinguished by the type of endosperm and the grain colours. (Anyanwu, 1979), Maize can be classified based on the endosperm character as follows:

Dent corn (*Z. mays indentata*): The most widely of colour but some are yellow or white in most commercial varieties. Dent type is high in lysine content with essential amino-acid.

Flint corn (*Z. mays indirata*): The endosperm is usually soft and starchy in center, but enclosed by a corneous outlayer. It is widely grown in California.

Floury corn (*Z. mays anylacea*): This has a very thin pericarp and a large amount of white starchy endosperm, which is soft. This type is very susceptible to weevil attack.

Pop corn (*Z. mays truricata*): The kernel is enclosed in a pod of husk. The typical podded ear will never bred true.

Sweet corn (*Z. mays sacchorata*): In this type, instead of all starch granules, we have sugary granules with very little starch granules. This type wrinkles on drying. In West Africa, various varieties have been introduced in an effort to produce varieties that are resistant to maize rust and adaptable to local conditions. In Nigeria, such varieties include: NSI, Haiti Tsola and various Mexican varieties (Anyanwu, 1979).Former Bendel State now Delta and Edo State Agricultural Development Project (ADP) with the aim of increasing farm yields and product, better quality crops has recommended the following varieties of maize to be planted in the State TZSR-W, TZSR-Y, TZESR, and Y and Y and TZES R-W (ADP Folder No. 17. 1990). The experiment stations of both the states and U.S. Department of Agriculture have co-operated in the work, approximately in the decade following 1934, more improved varieties of maize that are resistance to maize smut and maize rust were distributed to American farmers.

Soil and climatic requirements

Maize should be planted in well drained soil, sandy, loam to clayey loam, which is rich in humus and plant nutrients (Anyanwu, 1979). The soil should be alkaline or almost neutral. Maize does poorly on heavy soils, sandy or gravelly soils. It requires a minimum temperature of 10°C and maximum of about 46°C; hence it has a very wide temperature range. It has an optimum temperature requirement of about 33 to 34°C. The good performance of maize production does not depend so much on the amount of rainfall, but on the distribution, which is ranges from 75 to 150 cm per year. Maize has a very low ability of extracting water from the soil, so it must have steady water supply during its critical growth period. Otherwise, the performance and crop yield will be very poor. Hence, it is advised that the planting time for early maize should be done in March or April, while latte cropping of maize is August or September. The best pH range for maize cultivation is between 5.5 and 8.0.

Processing and storage of maize

Maize can be harvested dry or green. If maize is wanted green, it should be harvested soon after the silk has turned brown and if you want to harvest dry, you should harvest when the silk has completely dried up and the leaves and husk are also dried up. In Nigeria, early maize is harvested between May and August and late maize between November and December (Anyanwu, 1979). The Nigeria Stored Products Research Institute has recommended that maize may be harvested at moisture content well above the safe level of storage and drying to a level of below 15% moisture is desirable before removing the grain from the cob. Further drying to levels of moisture content below 12% will be necessary before safe storage can be conducted. In most area of Nigeria, sun drying of small quantities of maize is possible. Maize ears ox grains should be spread out in the sun and when necessary, protected from the rain. When ears are dry enough, they can easily be shelled manually or by use of manually operated shelling device where this is available. Selecting heat absorbent surface on which to spread the grain can facilitate sun drying particularly of the grain. Well cleaned area of concrete, flat stones or a flat roof metal or other suitable material are ideal and will give optimum benefit during sunny period. The grain when dry will be brittle and hard and should not feel damp when the hand plunged into the sun heated product (Williams, 2002). Your nearest secondary school chemistry section, or agricultural extension department may be in a position to asses the moisture content for you to ensure that the free moisture content is not more that 12% (for oven determination of moisture content, sample should be heated at a temperature of 120°C for 1 h or 105°C for 4 ½ h at intermediate temperature to constant weight. Alternatively, experience has shown that dry grains give high tone sound when dropped on their bulk, while wet grain gives low tone sound. This can be used to get a thorough idea of the dryness of the grain before storage dried grains can be stored in completely filled and hermetically sealed containers indefinitely. The following are considered suitable baby milk tins, bottles, kilner jars and clean oil drums. In adequate sealing or incomplete filling could lead to serious insect attack (NSPRI Advisory Booklet No.1;1982). Grain drying is a contest of race between the time required for the grain to dry down to a moisture content that allows for long-term storage and the time required for the heat of respiration and microbial growth at high moisture quality of the grain, therefore, classification of drying is in two broad ways (Aworrh, 1999):

Non-mechanical system: These are simple solar dryers and cribs that do not required artificial heating and fans.

Forced-air dryers: These are mechanical dryers using artificially heated air and fan for drying. They are complex in design, operation and management. He also said that dried grains could be determined by the use of moisture meters but when not available, the following simple method could be used:

1. Mixing a handful of the grain with salt, if the salt becomes lumpy, then it is not sufficiently dry;
2. Biting a few kernels of the grain feels very hard, almost as hard as stone, then it is most likely sufficiently dry;
3. Squeezing a handful of the grain as hard as possible, if the grain sticks together, then they are not sufficiently dry.

A variety of traditional methods are used for storage of grains. Some are more effective then others. successful application of some of the technique depends on the nature of the grain being stored and its resistance to storage pest unhusked maize cobs may be hung in bundles from trees ox some times tied to poles stuck vertically in the ground in the field ((Aworh, 1999).

Causes of post-harvest losses in maize production

The susceptibility of grains to microbial growth is determined by their water activity (Aworh, 1999). The higher the water activity, the more liable is the maize grain to microbial deterioration. When food grains containing a certain amount of moisture are exposed to air, there would be an exchange of moisture between the grain and the environment until there is an equilibrium moisture content (E.M.C) (Aworh, 1999). Therefore, for long-term storage grains must be dried to moisture content in equilibrium with a relative humidity of not more than 70% at 27°C (Hall, 1970). This optimum moisture content depends on the nature of the grain and varies from commodity to commodity; consequently, spoilage due to bacteria and moulds is more likely to occur at higher temperatures because of higher water activities. Farmers who store maize for human consumption for long period in sheath above the safe level of moisture content usually observe little deteriorations (Broadbent, 1971). Fluctuation in temperature of stored grain can be caused by insects in mould or by ambient temperatures that may heat or cool the periphery of the container and the out layers of grains; this may cause moisture movement by evaporations and condensation which favour mould growths. "The importance and control of micro-organism in crops during storage" presented during the training workshop organized by "Shell Petroleum Development Company" (S.P.D.C) Warri on the 6th of December, 1999, listed delayed harvest, damaged at harvest (mechanical injury), high moisture in crops during handling especially under high warm, humid tropical temperature, delayed and inadequate drying of grain and harvesting of immature crops as factors which can pre-dispose maize to microbial attack (Afolabi, 1999). The chemical treatment of maize grain after harvesting and drying will prevent food losses in maize production (Walter, 1977). In order to achieve the goals of food losses reduction in maize production, insect pests of maize grains must be controlled. The loss of food grains during storage due to insect pests has long been a serious problem to maize farmers. In many tropical countries, maize is a staple crop and *Sitophilus zeamis*, was the major pest in storage with percentage weight losses in storage estimated to be 30 to 80% using damaged grains and a conversion factor. Loss of maize grain, caused by *S. zeamis,* means that resources such as time, labour, land and money spent in growing the crop are wasted. The control of insects by insecticide has serious drawbacks, such as the development of resistant strains, toxic residues and increasing costs. A survey of the insect attacking grains has been made in number of African Countries. An investigation in Ahmadu Bello University, Zaria reveals that scania beetle causes weight losses of maize stored for 3 to 6 months; it average 10%. Some were found to be more than 30%. For post-harvest losses caused by insects, reliable estimate on individual country basis are difficult to obtain because of the variety of storage method used, the continual changing quantities in store and the trading practice adopted. Beetle and moth, which feed and multiply in stored grains result in considerable loss of food stuff (Watters, 1971). Insects, feeding on farm produce, result in the reduction in weight of the farm produce (Dobie, 1973). He however maintained that loss in weight might, also be due to reduction in moisture of the produce during storage. Insects feeding on stored maize resulted in reduction of nutritive value and quality (Girish, 1973). Rodents cause considerable field and storage losses of grains (Aworh, 1999). The most important species of rodents responsible for much of the damage to stored products in the tropics include:

(1) *Rattus*: It is an indigenous rodent pest of stored products in Africa
(2) *Rattus rattus* (Roof rat): This is by far the most widely distributed and most important rodent pest of stored products World Wide.
(3) *Rattus norvegicus* (Norway rat): The distribution of this species in tropical of Africa is less wide spread.
(4) *Mus musculus* (House mouse): this species causes considerably less damage to stored products relative to the others.

Rodents damage stored grains in the following ways:

1) They eat virtually anything that men and domestic animal would eat;
2) They contaminate grains with their fasces, urine, hair and other debris. Infact, the amount of food eaten by rodent is only about 10% of that they contaminate;
3) They gnaw holes in containers resulting in considerable spillage of grain. Jute bags are particularly susceptible to

rodent attack;
4) They transmit several dangerous diseases including the bubonic plague.

In general, loss of produce due to rodent after harvest can be obtained only in relation to the population densities of rodents in specific townships or warehouses (Majamber, 1968). Maize grains when mechanically damaged or wounded during harvesting/processing or damaged by other agents such as insects or rodent, they become more liable to mould attack which automatically begins on the wounded or damage surface or spot. This is because such exposed surface is damper and act more or less like a culture medium for moulds to grow. It is a common feature of all stored produce (grains, tubers, cocoa, beans, groundnut etc. and this is the reason why some storage moulds are found on grains at harvest, in addition to a few field fungi, which naturally attack them at that stage) (Afolabi, 1999). Mould attack some produce during the process of preparation of such produce for market, as a result of some lapses in cultural practices (Oyeniran, 1978). According to him, when grains are heaped on the ground especially those with high moisture content, there will be mould contamination, resulting in the deterioration of grains. Direct spoilage such as rotting of yams and caking of maize is usually caused by extensive mould infection and damage of these products during storage (Oyeniran, 1975; Broadbent, 1968; Okafor 1966). A study of the economics of storing grain in warehouses in Nigeria was embarked upon and it was observed that poor storage structures do not provide adequate protection against rain, insects and rats poor hygiene makes the grain susceptible to mould and pest infestation (Adesida, 2001).

Ways of reducing post-harvest food losses in maize production

The achievement of self food sufficiency aspiration in maize production of the nation, now and future can only be obtained by reducing past harvest food losses through the appropriate agricultural technique of transportation, treatment of grains, provision of good storage structures and methods including favourable environment devoid of pests infestation and microbial activities .Government efforts to find a solution to food shortage in the country have always emphasized increasing food production. generation of planners have identified Extension Research Liaison Services (ERLS) programme, among others as a major constraint, which is probably played down in reducing the loss of food crops during pre and post-harvest (Agboola, 1980). The National Accelerated Food Production Programme (NAFPP) which started in 1973 was aimed at developing a comprehensive package of technology that farmers could adopt t ensure high yields in major food crops (maize, rice, millet, sorghum, cassava and wheat) through the transfer of available improved agriculture research findings that will help reduce food losses to farmers. Some successes with regard to transformation of traditional agriculture were achieved (Egbule, 2002). The Nigerian Agricultural Insurance Scheme, which was launched in December 1987 with the intention of reducing risk and uncertainties, associated with agriculture. These range from unfavourable weather conditions pests disease flood fire out break pre and post-harvest losses and product prices (Egbule, 2002). A study of the economics of storing grain in warehouses in Nigeria was embarked upon (Adesida, 2001). She selected warehouses of capacities, 1000, 2000, and 5,000 tons for economics analyses of storing maize, guinea corn and cowpea in ware house in Nigeria. The main reason for conducting the study was to provide guidance and facilitate investment decision-making by those interested in establishment of warehouses for storage of grain. Traditionally, small scale farmers have stored their year's supply of grains in cribs hung on trees and stored in house ceilings. These structures do not provide adequate protection against rain, insects and rats poor hygiene makes the grain susceptible to mould and pest infestation. Therefore to make some money from grain storage and reduce post-harvest losses these traditional methods are not to be chosen. The scientist reported that the storage of grain in warehouses is the only recommended method, which will not pose technical problems o the users. Warehouses are preferred to conventional silos because of the problem of moisture condensation in these silos that lead to loss of grain stored in them. Improvements that have been introduced to silo storage of maize by Nigerian Stored Products Research Institute (NSPRI) have solved the problem of maize storage using silos. These improvements include: making them air tight shading them on top with palm leaves or grass and using nitrogen atmosphere to protect stored grains. These have completely solved the problem of condensation, moisture migration and insect damaged. The technology was developed and described as inert atmosphere storage of grains. It has given 100% protection to grain stored for up to 2 years (NSPRI Advisory Booklet No.1; 1982). In recent years, many workers have given greater attention to the control of stored grain pests using vegetable, essential and mineral oils, plant extracts and synthetic insecticides as protectants for stored grains for example stored maize (Jadhav and Jadhav, 1984). Physical methods of insect control have been recommended (Walters, 1971). He stated that control in any form depends primarily upon making the environment unfavourable for the pathogens, but suitable for the safe keeping of food produce. Various works have been carried out in recent years to evaluate the effectiveness of insecticides applied as dilute to maize cobs stored in local crib (Broadbent, 1971). The Nigerian Stored Products Research Institute (NSPRI) recommended method of pest control of produce stored in bag is by fumigation. This is the process of introducing insecticides known as fumigation, which release poisonous gas that kills all the insects in the produce. For this reason, the exercise is carried out either in a completely airtight store or the stack bags are covered by gas proof sheets. The fumigants currently in effective use are phostoxin tablets and pellets, applied at the rate of 4 to 5 tablets per ton of grain. The Nigerian Stored Products Research Institute (NSPRI), recommended that maize may be harvested at moisture contents well above the safe level of storage and drying to a level of below 15% moisture is desirable before removing the grain from the cob. Further drying to levels of moisture content below 12% will be necessary before safe storage can be conducted (Advisory Booklet No. 1, 1982).

REVISION

The outcome of this review showed that heaping of maize in one place or loading them in a sack for a long time causes mould to form. Also poor storage structures (bulk storage facilities and warehouses), improper handling during harvesting resulting in mechanical injuries cause losses in maize production with improper drying before storage causes loss in maize through deterioration. The methods of transporting maize from the farms to the store and the re – absorption of moisture from humid air during storage through the use of inappropriately designed and crack storage materials causes deterioration of the stored maize thereby reducing the quality and the market value of the grains. A good agricultural management practices through the combination of both preventive and control measures such as the appropriate techniques of harvesting of grains, transportation, treatment of grains, provision of good storage structure and favourable environment devoid of pests infestation and microbial activities will minimize the losses in maize production.

CONCLUSION

Having looked at the problems, of food losses in maize production in its entire ramification, it is therefore obvious that food losses in maize production are a product of many variables, some of which are inter-woven. Example of this could be seen from *S. zeamis* which has the gradient of infestation from the field (pre-harvest) to the store (post-harvest). Therefore, losses due to it are difficult to assess precisely because of the stages involved.

RECOMMENDATIONS

Based on the findings, the following recommendations are made:

1. Traditional effective methods for preventing and reducing post-harvest losses need to be indentified and exploited; this includes maintenance of continuous supply, storage for restricted periods, and transformation of durable products (maize grains and legumes). Some valuable traditional technologies for food preservation are in danger of becoming lost because they are being superseded by more sophisticated methods of doubtful long-term value. Modern and technology-intensive methods should be applied appropriately according to prevailing conditions including cultural factors, efficient and proper management of such technologies is as important as the types of equipment and facilities selected;
2. The entire food production and supply system needs to be addressed as a whole because of the interrelationship between and amongst the different components of the system. A substantial amount of post-harvest losses have their origin in the pre-harvest stage for example, genetic factors, infections, pest infestation, environmental factors and cultural practices during the production stage. On the other hand, *S. zeamis* the major pest of maize grain in the store has infestation from the field;
3. Sanitation in all post-harvest operations is a key factor in eliminating sources of infection and reducing levels of contamination;
4. Department of post-harvest technology should be established in all faculties of Agriculture in Nigerian Universities. This will ensure the availability of trained manpower to conduct effective post-harvest research;
5. Research/extension activities to be geared up so that available technology is made known to all users;
6. Periodical training workshop on storage of produce is organized for maize farmers. There is need for international information network;
7. Proper management of temperature and humidity of crops in the initial post-harvest period is essential in minimizes infection by micro-organisms;
8. A key factor influencing the magnitude of post-harvest losses is severity of mechanical damage to the crop during harvest and subsequent handling because it provides pathways for invasion by fungi and bacteria;
9. The users of post-harvest chemicals must ensure that the dosages and residues conform to internationally accepted maximum levels; for example, the FAO/WHO codex alimentarius commission;
10. The Nigerian Stored Products Research Institute (NSPRI) should be given sufficient funds to execute its research programmes on effective crop storage in Nigeria. This will help in reducing pre and post-harvest food losses.

According to the Irish ambassador to Nigeria, Kyle O Sulliva, on the 8th October, 2008 at the International Institute for Tropical Agriculture (IITA), Ibadan, said that the funding of research in food production and security was one way to tackle the global problem of rising food prices.

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