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MAIZE IN GHANA: AN OVERVIEW OF CULTIVATION TO PROCESSING

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Abstract.

Maize (Zea mays L.) cultivation in Ghana has been ongoing for centuries. Maize production in Ghana, is predominantly done under rain-fed conditions by poorly resourced smallholder farmers. The agro-ecological zones for maize cultivation in Ghana can be mainly grouped into four; Coastal savannah zone, forest zone, transition zone and Guinea savannah zone. Maize accounts for 50% of the total cereal production in Ghana, with reported postharvest losses between 5% and 70%. Improving food security through a reduction of post-harvest losses is imperative for meeting current development objectives. Stored maize is attacked by 20 different species of insect pests including the maize weevil, Sitophilus zeamais (Mots.). There are traditional techniques still in use for maize storage (drying in field, on platform, on ground, and use of mud silos) and modern techniques (using metal silos, solar dryers, chemical, hermetic technique and Purdue Improved Drying Stove). There are various methods used in the maize shelling and storage. Purchasing of modern equipment for shelling and conditioning is highly unaffordable by these subsistence farmers. The lack of commercial or industrial processing of maize, and improper storage facilities is causing immense food losses and insecurity in Ghana. Due to this farmers are compelled to sell their bumper harvest at low prices, and those in barns and warehouses get rotten. The purpose of this paper was to review literature on the cultivation, post-harvest handling, and processing of maize grains in Ghana.

***Keywords**: Ghana; maize; production; processing; storage.*

Introduction

Maize (*Zea mays* L.) cultivation in Ghana has been ongoing for centuries. After its introduction in the late 16th century, it got established as an essential staple crop in the southern part of Ghana. Maize is the most widely produced and consumed cereal crop in Ghana and maize production has seen increasing trend since 1965 (Morris *et al*., 1999; FAO, 2008). Maize production in Ghana, is predominantly done under rain-fed conditions by poorly resourced smallholder farmers (SARI, 1996).

Maize production is worldwide and has been a staple food for most people in the different parts of the world. There are no known toxins reportedly associated with the genus *Zea* of which maize belongs (IFBC, 1990). Maize is a major source of calories provider in Ghana, and report indicated that it has nearly replaced sorghum and pearl millet as traditional staple crops in northern Ghana (SRID-MoFA, 2011). The average yearly maize production was reported to be 1.5 million MT between MY 2007 and 2010 (Rondon and Ashitey, 2011) with an average yield of about 1.7 t/ha (SRID-MoFA, 2011). Maize accounts for over 50% of the total cereal production in Ghana, and annual yields have been reported to be growing around 1.1% (IFPRI, 2014). The purpose of this paper was to review literature on cultivation, post-harvest handling, and processing of maize grain in Ghana.

Areas of Cultivation

The agro-ecological zones for maize cultivation in Ghana can be mainly grouped into four (Figure 1). The system of maize cultivation differs among these agro-ecological zones (Morris *et al*., 1999).

- ***Coastal savannah zone***:

The coastal savannah zone comprises a narrow belt of savannah that runs along the coast, and widens towards the east side of Ghana. Maize mostly intercropped with cassava are grown by farmers. This zone experiences bimodally distributed annual rainfall totaling around 800 mm, and maize planting normally begins at onset of the major rainy season (March or April). Low productivity has been reported due to the light soil texture and low fertility.

- ***Forest zone***:

The forest zone lies down just inland the coastal savannah. Most of Ghana's forest is semi-deciduous, with a small area of high rain forest in the South-Western part of the country close to the border with Côte d'Ivoire. The cultivated maize is mostly intercropped with cassava, plantain, and cocoyam. The annual rainfall averaging about 1,500 mm is observed, and maize is planted both in the major and minor rainy seasons (March and September respectively).

- ***Transition zone***:

The forest zone gradually gives way to the transition zone towards the Northern part of Ghana. This zone is an important area for commercial grain production, and is characterized by deep, friable soils, and the relatively sparse tree cover allowing for progressive cultivation. Annual rainfall averaging about 1,300 mm is bimodally distributed. Maize cultivation is done both in the major and minor rainy seasons mostly as a monocrop or intercrop.

- ***Guinea savannah zone***:

Most of the lands in the Northern part of Ghana are in this zone. There is a single season of rain per year averaging 1,100 mm. Although sorghum and millet are the predominant cereals, maize is equally grown. Maize can be intercropped with legumes and other crops.

Figure 1. The agro-ecological zones in Ghana (FAO 2005 (modified), RESPTA 2008)

Generally, maize production happens in almost every part of Ghana, but more than 70% of the maize output is from three of the agro-ecological zones (guinea savanna, forest savanna and transitional zones). The five principal maize growing areas are in the Northern, Brong-Ahafo, Ashanti, Central and Eastern Regions (Amanor-Boadu, 2012).

Consumption and Cost of Maize

Reports indicate that 90% of the world's calorific requirement is provided by only 30 crops, with wheat, rice, and maize alone providing about half the calories consumed globally (MA, 2005b).

The per capital consumption of maize in Ghana in 2000 was estimated at 42.5 kg (MoFA, 2000) and an estimated national consumption of 943000 Mt in 2006 (SRID-MoFA, 2007). One million metric tons of maize is reported to be marketed annually in Ghana. A very large quantity of maize grains produced (Table 1) remains within households of producers as a primary staple food (Gage *et al.*, 2012).

The maize grain is consumed in different forms in various traditions and cultures and large proportion of the maize is used in the poultry industry as feed. Only about 20% to 25% of the total maize marketed is used for industrial processing and purposes. The wholesale price of maize is dependent on proximity to markets (location and transport), and the year's season, with prices generally high during the off seasons (Amanor-Boadu, 2012).

Table 1. The estimated Ghana's Maize Market Composition (Gage *et al.*, 2012).

Quantity (MT)	% of Total Consumption	% of Marketed Maize	
1,785,000			Total maize consumption
801,000	45		Subsistence consumption by producer. Households & post-harvest losses
410,000	23	42	Animal feed market (largely poultry)
328,000	18	33	Human consumption (informally traded)
246,000	14	25	Formally traded for processing (industrial & processed food)

Post-harvest Handling and Losses

Quality cannot be compromised in the agricultural production chain, and post-harvest handling of produce is a critical factor in determining standards and quality. Post-harvest handling involves the management of produce before processing which involves drying, storage, protection against pests, and moisture regulation. This step importantly requires quality control processes, a key in competitive products marketing.

There has been the application of traditional methods since olden days to preserve produce until the emergence of modern, and advance post-harvest techniques. The benefits of modern post-harvest handling are many, and most farmers in Ghana appreciate these processes.

Ragasa *et al*. (2014) reported that maize accounts for 50% of the total cereal production in Ghana, and reportedly has postharvest losses of between 5 and 70% (FAOSTAT/FAO Statistical Division, 2012). To improve food security there should be a reduction in post-harvest losses (PHL). Because losses increase cost of produce and thereby reducing consumers' purchasing power, divert income out of farmers' pockets, and hinder food availability (Opit, 2014). This report also indicated that the amount of grain stored in warehouses in Ghana is rapidly increasing, and a number of private and public sector organizations have formed Postharvest Service Centers (PSC) to increase agriculture production, food quality, and reduce PHL. The grains held by PSC are stored in warehouses and are virtually not given protection from insects and pests, and atmospheric air.

The National Food Buffer Stock Company (NAFCO) purposely created by Ghana's Government was to reduce post-harvest losses, ensure price stability, and establish emergency grain reserves (Rondon and Ashitey, 2011). NAFCO is a state-owned enterprise buys, preserves, stores, sells, and distributes excess grains mostly maize in warehouses across the country. Africa, and inevitably Ghana cannot afford to experience 20% or more grain PHL (World Bank, 2011).

Post-harvest Storage Methods

Stored maize can be attacked by 20 different species of insect pests including the maize weevil, *Sitophilus zeamais* (Mots.) (Coleoptera: Curculionidae), and the larger grain borer (LGB), *Prostephanus truncatus* (Horn) (Coleoptera: Bostrichidae). It has been reported that 90% worldwide postharvest losses are due to insects, and mite infestation; and therefore the need to control them (Vachanth *et al*., 2010). Owusu-Akyaw (1991) reported that about 20% of maize and cowpea produced annually are lost to *S. zeamais*. The produce can be contaminated with insect bodies and frass, and toxic chemicals like quinines (Kabir *et al*., 2011).

There are various traditional and modern techniques used for storing the maize grains or cobs.

- **Traditional techniques**

Maize drying is to allow a moving, relatively less humid and dry air takes moisture away from the grain**.**

- *In-field drying*

The cobs may be stacked or 'stooked' in the field to allow for further drying. Further losses are likely to happen due to more scattering, and exposure to pests and insects.

- *On-platform drying*

Threshing of grain is mostly preceded by further drying in homesteads. The maize cobs may be hung on racks or placed on purposely constructed platforms (Figure 2). This method has many advantages compared to the in-field drying but the percentage of grain loss is relatively high.

Figure 2. Different platforms for maize drying (Hodges, 2001)

- *On-ground Drying*

The grains are typically spread-out on the ground floor to allow drying (Figure 3). The grains which may be on the bare floor could absorb moisture, be contaminated with dirt and foreign materials, and also be exposed to rains, insects, pests, livestock and birds. In recent times, people are commonly drying maize on plastic sheets or mats. This practice of ground floor drying is discouraged because of the following reasons (UMA):

• Have to keep watch all the time to keep the grains from rain and etc.

• Grains can be washed away when there is a sudden down pour or be brought under shelter at night or when about to rain.

• There is higher risk of contamination from dusts, soil, stones, animal droppings, fungal, and insect infestation.

• Losses from birds, poultry and domestic animals, and quantitative losses are very high.

• The method is time consuming, and can be labor intensive when harvest is huge. Unfortunately, this method is the most practiced by farmers.

Figure 3. On-ground drying of maize grains (World Bank, 2011)

- *The use of mud silos*

The use of mud silos was commonly practiced in the Northern part of Ghana (Figure 4). These silos are constructed with mud and roofed with grass straws in which the grains are kept for storage. Considering the different methods discussed, this method is the best but losses are still relatively high.

Figure 4. Mud silos for maize storage (IITA)

- **Modernized techniques**
  - *The use of metal silos*

Farmers now store grains relatively safe in affordable metal silos (Figure 5). These metal silos minimize or prevents to a larger extent exposure to pests, insects and the weather conditions, and help increase food security

(Proctor, 1994).

Figure 5. Metal silos for maize storage (CGIAR, 2013)

The relatively high costs of the metal silos is a challenge now because the smallholder farmers consider it expensive to buy as an individual (FAO, 2008).

- *The use of solar dryers*

Solar dryers help reduce grain moisture to the safest level and therefore storage can be done safely for quite a longer period (Heinz, 1995). Solar drying can be used to dry all food types and considered an efficient preservation technique in Africa. More importantly, the solar drying operates in a clean, and hygienic environment with minimum labor and space required. Like metal silos, the solar dryers are relatively expensive, and therefore not priceworthy to be owned by individual farmers (Balakrishnan, 2006). Some farmers' cooperative could own solar dryers to be shared among members in order to reduce costs (FAO, 2008).

- *The use of chemical*

Farmers sometimes have to turn to the use of chemical control methods despite the associated health issues.

a. The use of fumigants and contact insecticides

Gaseous fumigants and residual contact insecticides are mostly used to control insects in stored grains (White, 1995; Obeng-Ofori, 2007 and 2011). The dried grains are fumigated, and then packed into bags for storage. Fumigants are reported not having residual effect, but can penetrate through stacks or bulk product killing all life stages of insects. The major draw backs in the use of fumigants are that they do not protect against grain re-infestations, they are extremely poisonous and could result in death if not well-handled (Danilo, 2003).

b. The use of layer by layer dusting of maize cobs (sandwich method)

The dried, and well-cleaned maize cobs are treated layer by layer as they are put into the granary. This treatment is efficient against most traditional storage insect pests of maize but relatively less effective in controlling large grain beetle. Some recommended chemicals used are Actellic 1%, Malathion 2%, Malathion 2%, Etrimfos 1%, Gardona 3.25%, and Methacrifos 2% (Danilo, 2003). The development of resistant insects strains, and health hazards to grain handlers could broadly be attributed to widespread and overdose use of synthetic chemicals (Zettler and Cuprus, 1990; White, 1995; Obeng-Ofori *et al*., 1998). Annual cereal grain losses could be up to 50% even with the heavy chemical usage although the average losses stand at roughly 20% (Obeng-Ofori, 2011). Misuse of insecticides by farmers is predominant and health and environmental problems are inevitable (Baributsa *et al*., 2010).

- *The use of hermetic technique*

To overcome the problems associated with fumigation and insecticides use, hermetic (airtight) storage technology is the most appropriate method.

Calderon and Navarro (1980) pioneered modern hermetic storage in Ghana which consisted sealed storage system containing a modified atmosphere. This technique is based on the principle of creating oxygen depletion and increasing carbon dioxide in the ecological system of sealed storage structure (Navarro *et al*., 2001; Obeng-Ofori, 2011). Research has shown that hermetically stored grains maintain their freshness and taste, seeds maintain their vigor and the ability to germinate. The first triple-layer hermetic bags used in Ghana was developed by the Purdue University (Figure 6), and was effective in storing cowpea. The Purdue Improved Cowpea Storage (PICS) bags consists of two sealed plastic (polyethylene) bags placed inside a third woven nylon or polypropylene bag for strength. These bags are now called Purdue Improved Crop Storage (PICS) bags used in storing all sorts of grains including maize. The effectiveness of the PICS bag in controlling *Sitophilus zeamais* (Mot) has been tested in Ghana. The results showed that the PICS were effective against *S. zeamais* and can be used for grains storage (Anankware *et al*., 2013).

Figure 6. Purdue Improved Crop Storage (PICS) Bags

- *The use of Purdue Improved Drying Stove (PIDS)*

Farmers who primarily depend on open-air sun drying are faced with challenges as harvesting coincides with the minor rainy season. Grains not dried to safe moisture levels cannot be efficiently stored using PICS technology. To enhance drying and quality of grains, and also not to compromise the credibility of the use of PICS bags, the PIDS (Figure 7) was tested in Ghana (Ileleji, 2012).

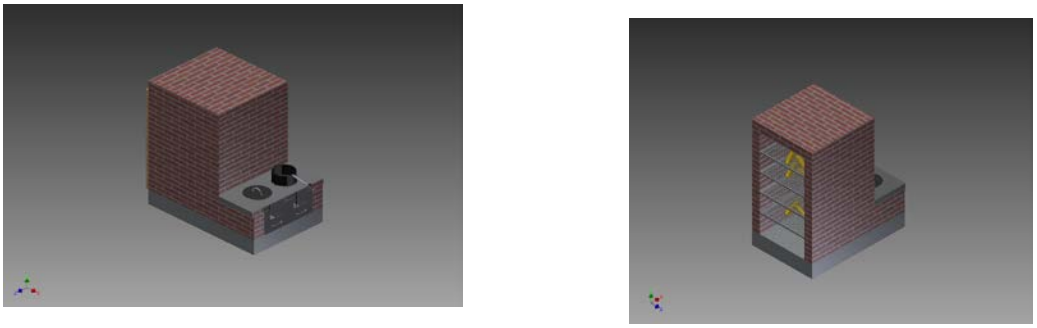

Figure 7. PIDS Technology (Ileleji, 2012, PIDS-I Prototype)

This technology was tested and is not on commercial use although the technology is been improved. This technology works on the principles below:

• It combines an efficient cooking stove and crop dryer in one unit.

• The concept is an indigenous idea but optimized with engineering.

• Corn cobs are used as fuel to reduce drying energy and save firewood use.

Some observed setbacks which limited the use of this technology were:

a. Production of smoke and coloring from soot.

b. Controlling heat loss and maintaining target temperature of 60°C in chambers 1 and 2 was a challenge.

c. Wind control during operation was a challenge.

d. There is the need to understand the use of different biomass fuels, and also modeling using CFD to understand heat transfer dynamics.

Shelling and Cleaning of the Grains

The most recommended way to store maize is in a shelled form. In many rural areas of developing countries including Ghana, the maize kernels are shelled mostly by using the fingers. Shelling the maize harvest by hand (Figure 8) typically takes weeks. The shelling becomes painful and cause injuries to fingers when the kernels are hard to shell. In situations where harvest is very huge shelling is commonly done by loading sacks with the maize cobs and the loaded sacks are beating with sticks. The beating may result in physical damage to the grains making the grains more vulnerable to pests and molds, and also causes germ damage. The use of industrial maize shellers and small-scale hand-cranked or pedal-powered maize shellers are often unaffordable or difficult to obtain by subsistence farmers. Simple tools have been developed to make it possible to shell maize several times faster than by the fingers. These tools have been developed in different types and sizes using locally available materials (Figure 9). Recently, some individuals are owning shellers that they render services to farmers. The owners operate in the act of barter trading, where they take one bag out of the total ten shelled bags. Cleaning of shelled grains is an important step to consider, and this is done by winnowing which involves letting the grains drop from a height and allowing natural air to carry the chaff and foreign materials out of the grains. This method however is time consuming, tedious, inefficient and causes grain losses. Grain cleaning makes the grains wholesome, increases market value, and reduces mould and insect development.

Figure 8. Shucking and shelling corn in rural Ghana (MIT, 2015).

Figure 9. Different types of local maize shellers (MIT, 2015)

Transporting the Grains

Transporting maize grains is equally a herculean task, and the process also can result in insects and microbial contamination. The harvested maize cobs are moved to the farm yard from the farm. The shelled grains are also transported from farm yards to various markets. Women and children are these who usually carry the produce either on their heads or shoulders to the various destinations. Harvested grains can be carried from fields or farm yards to different destinations by using motor trucks or cars but this is dependent on the availability of access roads and the costs affordability of the farmer. The means of transport also depends on factors like quantity of produce, distances to be covered, availability of motor trucks (Danilo, 2003). The degree of grain deterioration when transporting grains is mostly proportional to the distance to cover.

Grain Processing

The growth in processed food sale is about three-quarters of total world food sales. Processed food makes up about half of the total food expenditures in developed countries, whiles in developing countries it comprises only a third or less (Regmi and Gehlhar, 2005).

Domestic use of maize is greatly predominate to industrial processing of maize in Ghana. Aside boiling or roasting of the whole fresh maize cob as meal, fermented meals prepared from maize are commonly eaten in most homes. Some examples of fermented maize meals in Ghana are “koko” (porridge), “banku”, “tuo zaafi”, “akple”, “kenkey” etc. Poultry and livestock feeds prepared from maize are the major industrial processing, and limited quantity of maize grains are processed onto shelves. The limited commercial or industrial processing of maize is causing immense food insecurity in Ghana. Tonnes of maize got wasted in barns and warehouses in the Northern Region of Ghana following a glut in the market (Ghanaweb.com, 2013) which has been the phenomenon for decades. A glut in maize market sometimes leave many farmers impoverished as they are forced to sell their produce cheaply due to lack of proper storage facilities and industrial processing. It is also worth noting, the extent of grain rot in stored barns and warehouses during seasons of glut in maize.

Conclusion

Maize is the most important cereal crop produced predominantly by smallholder farmers. Maize production is dependent on the characteristic features of the agro-ecological zones of cultivation. Cultivation, harvesting, shelling, transporting, storage and processing of maize are still faced with challenges although some achievements have been made. Traditional and modern techniques are used to store maize grains although the methods used in shelling is relatively primitive. Purchasing of modern equipment for shelling and conditioning is highly unaffordable by these subsistence farmers. Commercial or industrial processing of maize should be encouraged to reduce losses due to limited storability to help increase food security in Ghana.

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