**KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY**

**COLLEGE OF AGRICULTURAL AND NATURAL RESOURCES**

**FACULTY OF AGRICULTURE**

**DEPARTMENT OF HORTICULTURE**

# DETERMINANTS OF POSTHARVEST LOSS IN MAIZE – A CASE STUDY OF EJURA – SEKYEDUMASI MUNICIPALITY OF ASHANTI REGION OF GHANA

**BY**

**BOATENG AMOAH BENJAMIN**

**MAY, 2016**

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**A DISSERTATION SUBMITTED TO THE SCHOOL OF RESEARCH AND GRADUATE STUDIES, KWAME NKRUMAH UNIVERSITY OF SCIENCE AND TECHNOLOGY, IN PARTIAL FULFILLMENT OF THE REQUIREMENT FOR THE AWARD OF DEGREE OF MASTER OF PHILOSOPHY (M.PHIL. POSTHARVEST TECHNOLOGY.) DEGREE**



**MAY, 2016**

## DECLARATION

I, BENJAMIN AMOAH BOATENG do hereby declare that, with the exception of the reference to other people's work, which has been duly acknowledged, this work is the result of my original research supervised by a lecturer, and that this work has neither in whole, nor in part, been presented for a degree elsewhere.



| | | |
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| Dr. Francis Appiah<br>(Head of Department) | ..... Signature | ..... Date |

## DEDICATION

This work is dedicated to my Lovely Family, Victoria Serwaa Amoah and my three lovely kids, Wendy, Terry and Marina my siblings and my dear parents, Madam Christiana Anokyewaa and Mr. Duodu Bediako Boateng for all their struggle and toil in bringing me to this level. I also dedicate it to Mr. And Mrs. Kodom for the support and encouragement in my academic pursuit. May the Good Lord richly bless you all



Siblings:

Fiifi, Happy, Constance, Gifty, Daniel, Hannah, Elvis, Rita, Benedicta, Kelvin, Denzel and Tori

**ACKNOWLEDGEMENT**

My ultimate gratitude goes to the Almighty God for his mercies, kindness and love to me from the beginning to the completion of this work. I wish to acknowledge my supervisor, Mr. Patrick Kumah, co- supervisor, Dr. Dadson Awunyo-Vitor and the

Head of Department Dr. Francis Appiah's encouragement and diverse contributions towards the completion of this study. Without their advice, criticism and directions, this work would not have been possible.

I also owe a debt of immense gratitude for the assistance offered me by Lecturers of the Department of Horticulture and postharvest technology of KNUST. Special thanks go to my fellow colleague students of the Department of Horticulture and Postharvest Technology who assisted me in my data collection

I further wish to thank The Meteorological Department of Ministry of Agricultural, (MOFA) Ejura, especially Mr. Stephen and all those who contributed in one way or the other towards the success of this thesis.

## ABSTRACT

Maize is known to be domesticated first in Mesomaria with its botanical name as *Zea mays L.* The versatility in its usefulness makes it one of the very important grains in the world as it can be used as food for both human and animals, the generation of energy (bio fuels), medicine, for brewing beer and even whisky, starch production, chemicals and many other purposes. This study was therefore aimed at determining the factors that influence postharvest loss in maize with Ejura-Sekyedumase Municipality as the study area. The study was conducted in two folds. Field survey and field experiment. Purposive sampling technique was used to select ten maize communities in the Ejura-Sekyedumase Municipality of Ashanti Region of Ghana, namely, Dromankuma, Kasei, Kyenkyenkura, Bemi, Sekyedumase, Drobon, Dejau, Teacherkrom, Ejura and Babaso. (120) respondents of farmers/producers and (50) marketers a total of (170) respondents in all were randomly selected for the field survey whilst field experiment was also done for the various stages of postharvest handling including harvesting, shelling/threshing/winnowing, drying, storage and transportation. The results indicated that the most dominant varieties of maize were Aburohoma and Obaatanpa which were widely cultivated because of their high yielding nature. The regression analysis indicated that, traditional storage and production length were significant at 1% whilst storage, household size and educational background were significant at 5%. The results further indicated that postharvest losses normally occur at every stage of postharvest handling with much losses occurring during the harvesting and storage stages 38% and 25% respectively of total postharvest loss. The field experiment also indicated that maize storage is still a major problem among maize farmers in the study area. In the field experiment, storage was the highest stage that postharvest occurred most (4.9%) followed by shelling, threshing, winnowing and harvesting (4.25% and 2.95%

respectively). Drying and transportation were the least stages where losses occurred, 2.05% and 1.4% respectively. Majority of the farmers in the municipality depend on traditional storage (crib) systems because they cannot afford warehouses. The Kendall's coefficient of concordance revealed that, lack of storage facility, non availability of shelling/threshing services and difficulty finding buyers were the three most important constraints faced by farmers in the study area with mean marks of 1.24, 1.36, 1.47 respectively whilst pilfering and pest infestation ranked least with a mean mark of 3.44 and 2.49 respectively. The highest stage where losses occurred most is the harvesting (38%) followed by storage stage of about 25% of total postharvest loss in the field survey results and the field experiment results also indicated that, storage stage is the highest stage where more losses occurred (4.9%) followed by shelling, threshing and winnowing stage of about 4.25%. In view of these findings these stages should be looked at critically since they affect postharvest loss positively in the study area.

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## 1.0 INTRODUCTION

In developing countries postharvest losses of grains are more serious than those in developed countries. In most developing countries the number of scientists concerned with postharvest handling research is significantly lower than those involved in production research (FAO, 2004).



Grains may be lost in the pre-harvest stages, harvest and postharvest stages. Preharvest losses occur before the process of harvesting begins and may be due to insects, weeds and rusts. Postharvest losses occur between harvest and the moment of human consumption. They include on-farm losses, such as when grain is threshed, winnowed and dried, as well as losses along the chain during transportation, storage and processing. Important in many developing countries, particularly in Africa are onfarm losses during storage, when the grain is being stored for auto-consumption or while the farmer awaits a selling opportunity or a rise in prices (Kenton and Lindblad, 1976). There is the potential for loss throughout the grain harvesting and agricultural marketing chains. During stripping of maize grain from the cob, known as shelling, losses can occur when mechanical shelling is not followed up by hand -stripping of the grains that are missed (Shepherd, 2012).

In Africa postharvest losses from harvest to market sale amount to about 10-20%. Approximately 40% of these losses occur during storage at the farm and market, 30% during processing (drying, threshing, and winnowing), 20% in transport from the field to the homestead/ farm, and the remaining 10% during transport to market threshing losses occur as a results of spillage, incomplete removal of the grain during the threshing (FAO, 2004).

Maize is produced and consumed worldwide making it an important food security crop. The versatility in its usefulness makes it one of the very important grains in the world as it can be used as food for both human and animals, the generation of energy (bio fuels), medicine, for brewing beer and even whisky, starch production, chemicals and many other purposes (Obilana and Fajemisin, 1977).



According to FAO (1998), addressing the issue of postharvest losses is of paramount importance as food production cannot meet the demand as much of it is lost before it gets to the final consumer. There is therefore the need to put in place structures, policies and programmes such as developing early maturing, high yielding, pest and disease resistant and drought resistant varieties of maize to help increase maize production at the local levels (Ajirenike, 2005).

Postharvest loss is a very important issue in Agriculture. This is because man has to live or survive by food. It is a very serious in Agriculture because, most households in Ghana and the Sub- Saharan Africa are not able to produce all that they require for consumption and the little that they are able to produce about five to ten per cent (5 – 10%) of it go waste as a result of postharvest loss (FAO, 1998).

Deductions can be made from the aforementioned that, postharvest loss of maize and rising prices of maize can and will have a telling effect on the incomes of the majority of the populace and the Nation at large. A concerted effort by all stakeholders towards the reduction of postharvest losses in maize and improvement of maize production provides a sure approach to food security. The net effect will be the freeing of more resources (time, finance and human resources) for investment in other sectors of the economy leading to higher development and betterment of the nation as a whole.

Most farmers in the Ejura-Sekyedumase Municipality of the Ashanti Region of Ghana are more into maize production but no assessment has been conducted to determine the postharvest losses of maize (both quantitative and qualitative). Over the years, determinants/ causes of postharvest losses of produce or crops has been attributed or centred mainly on the scientific point of view (like the larger grain borer, bad/ improper agronomic practices) like improper planting, poor spacing, untimely weeding, poor application of fertilizer, poor harvesting etc but there are other socioeconomic factors/ determinants that influence postharvest losses of maize like gender, marital status, level of education, household size, level of output, source of information, type/ place of storage, drying, threshing/ shelling, winnowing, bagging, loading and offloading, size of sack for bagging, transport among others.

This study was therefore aimed at determining the factors that influence postharvest losses of maize in the Ejura-Sekyedumase Municipality particularly the socio-economic aspects / factors apart from the scientific aspects in the light of increased utility of maize.

The specific objectives sought to:

1. ascertain the socio-economic characteristics of respondents in the Ejura-Sekyedumase Municipality;
2. determine factors that influence postharvest loss in maize in the study area;
3. identify the modes of handling of maize from harvest to the sales point and their effect on postharvest loses of maize at each stage of handling ; and
4. identify the constraints associated with postharvest handling of maize in the study area.

# 2.0 LITERATURE REVIEW

## 2.1 MAIZE LOSSES

The nature of loss makes it difficult to define as it varies from one industry to the other. It is of course much easier to estimate quantitative losses especially with tangible things (Hodges *et al.*, 2011). This further goes on to provide a clue as to the causes of the postharvest losses, which would give an idea as to the scale of measurement to use and how a particular crop should be handled.

The losses are calculated by taking a percentage of the total amount loss divided by the total amount. An overestimation of losses often happens when losses are calculated based on the "original weight" of the crop; there are other variables that are very difficult to estimate such as manual labour, farming inputs, opportunity cost, hopes, illusions and time (FAO, 1996). For the purposes of this study, the procedures for estimating postharvest losses are geared towards given an idea of the quantitative losses that occur after harvest (FAO, 1992).

## 2.2 POSTHARVEST LOSS

Postharvest loss can be defined as the degradation in both quantity and quality of a food production from harvest to consumption. Quality losses include those that affect the nutrient/caloric composition, the acceptability, and the edibility of a given product. These losses are generally more common in developed countries (Kader, 2002). Quantity losses refer to those that result in the loss of the amount of a product. Loss of quantity is more common in developing countries (Kitinoja and Gorny, 2010).

A recent FAO report indicates that at global level, volumes of lost and wasted food in high income regions food is lost and wasted at the lower levels while the vice versa is applicable for low income earning regions (FAO, 2013).

According to de Lucia and Assennato (1994) the loss in terms of the quantity and quality of food in the postharvest system is referred to as postharvest loss. The postharvest system consist of concurrent activities starting with the harvesting of the crop through to sale or processing of the crop until it gets to the final consumer who then decides whether to consume or discard it.

Tyler and Gilman (1979) defined postharvest loss for agricultural crops as the decline in either or both the quantity and quality of the food or crop. Mostly agricultural crops are said to still be living even after harvest as they still breath and could degenerate in quality and quantity based on the way they are handled after harvest. Often than not we interchange the use of damage and loss but the two are not the same. When a crop produced is damage, it means it has declined in quality and probably quantity and could still be used but when a crop produce is loss it can no longer be used at all. Along the postharvest chain there could be a loss either in quality or quantity or both at any time and stage of the chain and therefore extra care and caution should be taken when handle crop produce.

## 2.3 IMPORTANCE OF MAIZE

Depending on which region of the globe you find yourself, the importance of a particular food produce varies as there are several cultures across the globe which influence the food they eat. For Latin America and Sub-Sahara Africa maize has remained the most important cereal crop as it serves as food for a whole lot of people

in these areas (Folayan, 2013). Maize has many varying uses as it could be used for different types of foods, bio-fuel and even parts of it could be used for other purposes (Folayan, 2013). In Southern and Eastern Africa maize stands out to be one of the major expenditure components for households as it contributes close to half the expenditure (Nyoro, 2004).



The over dependency on maize as the major dietary supplement mostly leads to protein and some vitamin deficiency due to them being absent in maize (Nyoro, 2004). The world over the reliance on maize as a primary source of food cannot be disputed aside which maize is also used as a feed for animals and serves as a raw material for other products (Raouf, 2011). Some of the industrial products maize serves as raw materials for include but not limited to; syrups, beer, bio-fuels and now for the production of compostable containers and many others (Raouf, 2011).

Even though maize is deficient in protein and vitamin A, it is equally rich in other nutrients such as carbohydrates, vitamin C and E including other minerals that are of essence. In recent times maize breeds have been improved to contain some amount of protein and vitamin C. The nutrients contained by the maize grains helps in maintaining good health. The roughage also aid in avoiding constipation and in the removal of other toxic waste from the body which adds up to maintaining good health (FAOSTAT, 2012).

Table 2.1: Nutritional Value of Maize

| Content | Percentage dry matter basis |
|---|---|
| Starch | 71 – 72 |
| Protein | 9-10 |
| Fat | 4-45 |
| Fibre | 9 – 10 |
| Sugar | 2-3 |
| Minerals(Ash) | 1.4 |

Source: Technologies for processing specialty maize in India, Directorate of Maize Research, ICAR, New Delhi.

## 2.4 MAIZE VARIETIES IN GHANA

The Ghana Grains Development Project has introduced some new hybrids and varieties of maize as elaborated on below;

Aburotia 1984 White Dent 105 4.6 No No Tuxpeño PBC16

Dobidi 1984 White Dent 120 5.5 No No Ejura (1) 7843

Kawanzie 1984 Yellow Flint 95 3.6 No No Tocumen (1) 7931

Golden Crystal 1984 Yellow Dent 110 4.6 No No ——

Safita-2 1984 White Dent 95 3.8 No No Pool 16

Okomasa 1988 White Dent 120 5.5 Yes No EV8343-SR

Abeleehi 1990 White Dent 105 4.6 Yes No Ikenne 8149-SR

Dorke SR 1990 White Dent 95 3.8 Yes No Pool 16-SR

Obatanpa 1992 White Dent 105 4.6 Yes Yes Pop 63-SR

Mamaba 1996 White Flint 110 6.0 Yes Yes Pop. 62, Pop. 63-SR

Dadaba 1996 White Dent/flint 110 6.0 Yes Yes Pop. 62, Pop. 63-SR

Maize is the most important cereal crop on the domestic market in Ghana however its only the 7th largest agricultural commodity in terms of value of production over the period 2005-2010 accounting for 3.3 percent of total agricultural production value (FAOSTAT, 2012). Root crops such as yam, cassava and cocoyam, together with plantains are by far more relevant in terms of production value due to their paramount importance in the Ghanaian diet. Maize accounts for 55 percent of grain output followed by paddy rice (23percent), sorghum (13percent) and millet (9percent). Maize is also an important component of poultry feed and to a lesser extent the livestock feed sector as well as a substitute for the brewing industry. Maize average yield registered by the Ministry of Agriculture in 2010 was 1.9Mt/ha against an estimated achievable yield of around 2.5 to 4 Mt/ha (Ministry of Food and Agriculture, 2010). Maize production over the period 1990-2010 shows significant increases starting from year 2008. However, it was not possible to explain to what extent the production increase was due to the favourable rain patterns, the introduction of the fertilizer subsidy in 2008,the high food prices which could have stimulated domestic production over the period 2008- 2010 (Raouf, 2011).

## 2.5 MAIZE PRODUCTION AND POSTHARVEST LOSSES

Undisputedly maize is the number one staple cereal crop cultivated in Ghana as it is accounts for half of the total cereal cultivated in the country and it comes second to cocoa when it comes to the commodity crop largely produced in the country (Zorya *et al*, 2011). Even though produced largely by small holder farmers' maize is one of

Ghana's most important cereals as it contributes largely to food security (Zorya *et al*, 2011). Maize cultivation is still rain fed which accounts for the annual variation in

production levels and it is also highly dependent on traditional farming methods making the size of production and the quantity produced virtually constant (Tefera, 2012). With the current agricultural practices used in maize production, yields obtained are highly below their optimum levels that is from the field yield are averagely 1.5 metric tons per hectare while a farmer using fertilizer, irrigation, improved seeds and mechanization obtain between about 5 metric tons per hectare (Thamaga-Chitja *et al.,* 2004). This therefore makes it difficult to match up with the already out matched demand for maize in the country as the gap between supply and demand greatly widens (Thamaga-Chitja *et al*., 2004).

According to statistics (FAO, 1998), though maize is largely cultivated in the country that is about 650000 hectares its yield is almost always below 2 metric tons per hectare given a total annual yield of about 1 million tons. The maize crop is mostly grown with other crops especially in the forest and coastal savannah zones.

Roots and tubers contribute more calories to human diet to maize as maize contribute less than 20% of the total calories to a typical Ghanaian diet (Alderman and Higgins, 1992). For the northern part of the country maize is mostly used for T.Z. A local dish, banku, porridge and other dishes while in the southern part of the country maize is mostly used for kenkey, banku, porridge and other dishes. Maize contributes about 36% of calories to the diet of people in the areas in which maize is the main staple crop. In some surveys conducted by Alderman (1992) about 74% of the household that cultivate maize depending on the month start to find other means of purchasing maize to meet their demand for it, therefore promoting the trade of the maize grains in the country. The revenue generated from the sale of maize accounts for 17.65% of the total revenue source of poor households in the country (Boateng *et al.,* 1990).

## 2.6 GLOBAL MAIZE PRODUCTION AND POSTHARVEST LOSSES

Maize which is also called corn in many English– Speaking countries, is a grain domesticated by indigenous peoples in Mesomaria in prehistoric times (Raouf, 2011).

It is one of the most cultivated cereal crops worldwide (Suleiman *et al.*, 2013). As at 2012, world maize production was about 10.14 billion metric tons with the United States (US), the largest producer, producing about 30 % followed by China 21% and Brazil 7.9 % (De Groote *et al.*, 2013). Africa produces around 7 % of the total world production (Verheye, 2010; FAOSTAT, 2014).

Table 2.2: Area, Production and Yield of Maize in Major Producing Countries

| Country | Area ('000 ha) | | | Production ('000 tonnes) | | | | Yield(Kg/ha) | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | 2002 | 2003 | 2004 | % to world | 2002 | 2003 | 2004 | % to world | 2002 | 2003 | 2004 |
| 1.USA | 28050 | 28789 | 29668 | 20.44 | 228806 | 256905 | 298234 | 42.28 | 8157 | 8924 | 10052 |
| 2.China | 24661 | 24093 | 25584 | 17.63 | 121497 | 115998 | 131860 | 18.69 | 4927 | 4815 | 5154 |
| 3.Brazil | 11751 | 12957 | 12437 | 8.57 | 35933 | 47988 | 41947 | 5.95 | 3058 | 3704 | 3373 |
| 4.Mexico | 7120 | 7781 | 8000 | 5.51 | 19299 | 19652 | 20000 | 2.84 | 2711 | 2526 | 2500 |
| 5.India | 6662 | 7000 | 6800 | 4.69 | 10300 | 14720 | 14000 | 1.98 | 1546 | 2103 | 2059 |
| 6.Nigeria | 4490 | 4700 | 4700 | 3.24 | 4934 | 5150 | 5150 | 0.73 | 1099 | 1096 | 1096 |
| 7.Indonesia | 3127 | 3355 | 3353 | 2.31 | 9654 | 10910 | 11359 | 1.61 | 3088 | 3252 | 3388 |
| 8.S. Africa | 3350 | 3350 | 3200 | 2.20 | 10076 | 9705 | 8311 | 1.18 | 3008 | 2897 | 2597 |
| 9.Romania | 2895 | 3119 | 3000 | 2.07 | 8400 | 9577 | 13231 | 1.88 | 2902 | 3070 | 4410 |
| 10.Argentina | 2432 | 2323 | 2081 | 1.43 | 15000 | 15040 | 13000 | 1.84 | 6168 | 6475 | 6247 |
| 11.Others | 43880 | 45925 | 46319 | 31.91 | 138095 | 134419 | 148201 | 21.02 | 3147 | 2927 | 3200 |
| World | 138418 | 143392 | 145142 | 100 | 60194 | 640064 | 705293 | 100 | 4349 | 4463 | 4859 |

Source: FAO Production Year Book, 2004.

Maize can be useful in so many forms; as food and feed, alternative medicine, chemicals, biofuel, ornamental and other uses (Raouf, 2011). It is a major ingredient in home cooking and in many industrialized food products. Maize starch can be hydrolyzed and enzymatically treated to produce syrups, particularly high fructose corn –syrup, a sweetener, and also fermented and distilled to produce grain alcohol for whiskey production and as the starch source for beer (Raouf, 2011).

It is mostly used and traded as a leading feed crop but it is also an important food staple (Nyoro, 2004). Maize is an annual plant with high productivity which also enjoys exceptional geographic adaptability, an important property which has helped its cultivation to spread throughout the world (Folayan, 2013).

Maize belongs to the Gramineae family and grows annually with an average height of

1 to 3 meters sometimes greater than that. It has both the male and female flowers on the same plant therefore making it a monoeccious plant in which the female flower develops into the ear while the male flower serves as the tassel at the top of the maize plant. The maize cobs are usually formed at the middle of the stalk plant. The kernel determines the type of maize; therefore maize is grouped into seven based on the type of kernel.



Table 2.3 Types of Maize

| Type of Maize | Description |
|---|---|
| Flint maize | Kernel is soft and starchy in the centre and completely enclosed by a very hard outer layer. The kernels are usually rounded but are sometimes short and flat. White and yellow are mostly its colours and it is mostly cultivated in India. |
| Dent maize | A hard and soft starch are found in the kernels with the hard starch extending to the sides while the soft starch is at the centre and extends to the top of the kernel and it's mostly grown in the United States of America. |
| Pop maize | As the name suggest this maize has popping qualities with hard endosperms and small kernel. When heated it pops out and it is indeed suitable for pop corn. |
| Sweet maize | As the name suggest the kernel is usually sweet than most if not all maize grains and thus usually shrinks when dried and swells when soaked in water. |
| Soft maize | The maize grain of this type of maize is very soft and of various colours but have similar shapes as flint maize. |
| Pod maize | It is the prehistoric type of maize that has each maize grain enclosed in a husk it is currently of little value. |
| Waxy maize | It is very rich in starch as the starch produces some waxy appearance any time the grain is cut. |

According to (FAO, 1998), food production cannot satisfy the increasing food demand unless attention is focused on reducing postharvest losses. This will create an opportunity for providing a substantial amount of food for consumption and other uses.

Most of the postharvest losses are occurring in the developing countries while most of the increased food production is taking place in the developed countries (Folayan, 2013).

Postharvest loss (PHL) has been described as grain loss which occurs after separation from the site of growth or production to the point where the grain is prepared for consumption (Boxall, 1986 cited by Nyambo, 1993). Postharvest losses (PHL) have also been defined as measurable quantitative, qualitative, and economics of grain loss across the supply chain or the postharvest system, from the time of harvest till its consumption (Aulakh and Regmi, 2013; Tefera, 2012).

According to de Lucia and Assennato (1994) the loss in terms of the quantity and quality of food in the postharvest system is referred to as postharvest loss. The postharvest system consist of concurrent activities starting with the harvesting of the crop through to sale or processing of the crop until it gets to the final consumer who then decides whether to consume or discard it. Tyler and Gilman (1979) also defined postharvest loss for agricultural crops as the decline in either or both the quantity and quality of the food or crop.

A joint report of the FAO/World Bank in 2010 indicates that PHL of cereal account for over 40 % of the total PHL in SSA countries (Zorya *et al*, 2011). This represents losses of about $1.6 billion in value each year and also such losses are equivalent to the annual caloric requirement for at least 20 million people (FAO, 2013). These losses are also more than half of the value of total food aid received by SSA in a decade (Zorya *et al*, 2011).

Quality losses include those that affect the nutrient/caloric composition, the acceptability, and the edibility of a given product. These losses are generally more common in developed countries (Kader, 2002). Quantity losses refer to those that result in the loss of the amount of a product. Loss of quantity is more common in developing countries (Kitinoja and Gorny, 2010). A recent FAO report indicates that at global level, volumes of lost and wasted food in high income regions food is lost and wasted at the lower levels while the vice versa is applicable for low income earning regions (FAO, 2013).

### 2.6.1 Comparison between Losses and Waste

According to the FAO (2013), the terms loss and waste are often sometimes used synonymously but they have distinct drivers and, as a result, distinct solutions. “Food loss” refers to food that spills, spoils, incurs an abnormal reduction in quality such as bruising or wilting, or otherwise gets lost before it reaches the consumer. Food loss typically occurs at the production, storage, processing and distribution stages of the food value chain, and is the unintended result of agricultural processes or technical limitations in storage, infrastructure, packaging, and/or marketing.

On the other hand, “Food waste” refers to food that is of good quality and fit for human consumption but that does not get consumed because it is discarded either before or after it spoils. Food waste typically, but not exclusively, occurs at the retail and consumption stages in the food value chain and is the result of negligence or a conscious decision to throw food away.

The issue of food losses is of high importance in the efforts to combat hunger, raise income and improve food security in the world's poorest countries. Food losses have an impact on food security for poor people, on food quality and safety, on economic development and on the environment (FAO, 2011). According to FAO (2013) the reduction in the weight and nutritional value of edible food meant for human consumption is referred to as loss food. Unlike food waste, losses occur from the inception of production to the very last stage of the consumer finally consuming the food that is losses occur at every stage of the food chain (FAO, 2013). Food losses can be attributed to so many factors such as poor technology, logistics and infrastructure, lack of markets, the knowledge and management ability of the actors in the supply chain and insufficient skills (Parfitt *et al.,* 2010).

The leaving of wholesome food to go bad either before it expires or for it to expire or even discarded is referred to as food wastage. It basically occurs not from production but rather from harvesting that is from the retailers to the final consumer. Waste can sometimes include food loss but most often both food loss and waste refers to foods meant for human consumption while any products less than that are not considered as food waste and food loss (Hodges *et al.,* 2011). Food waste could still be managed for consumption and it thus also falls under food loss as it is from food waste that edible products migrates to food loss.

FAO (2011) disclosed that food loss and food waste is when an edible food fails to get to the final consumer for consumption due to several reasons. They further emphasized that the diversion of edible food for other purposes such as fuel generation and feed for animals is also considered as food loss and or food waste.

Below is a typical example on table according to Parfitt *et al.,* (2010) of food waste in the food supply chain;

**Table 2.3: Food waste in the food supply chain**

| Stage | Examples of waste |
|---|---|
| Harvesting, handling at harvesting | is loss at the field during harvest due to pest, time of harvest, left on the field or even ploughed back. |
| Threshing | The type of process used in threshing could cause food loss or waste. |
| Drying, transport and distribution | During drying both the quantity and quality of the produce is affected while failure to transport and distribute produce on time leads to them getting spoiled on the field. |
| Storage | Often at storage pest contaminate food through varying activities leading to spoilage and even their dead remains in the food equally contaminates it. |
| Primary processing | The initial process of cleaning, classifying and packaging including other methods of processing leads to the loss in quantity and quality of food produce. |
| Secondary processing | This is where the food is further processed into forms preferred by consumers through frying, roasting, boiling etc. Here food could also be loss or wasted because parts are cut await and wasted. |
| Product evaluation and quality control | At this point food is often loss or wasted because they do not meet certain standards due to them being of lower grade (in terms of packaging, size, nature of production, moisture content etc.) |
| Marketing, selling and distribution | The failure to package properly, sell and distribute grains on time and even during transportation leads to the loss or decline in quality of grains which could either lead to the discarding of the grains. |
| Post-consumer | Before serving, the poor preparation of food could lead to the consumer rejecting the food and therefore leading to food loss. |
| End of life disposal of food waste/loss | This is where foods have exceeded their life span and therefore have to be disposed. The prices could have been brought down to enable people purchase or better still sent to places where food is most needed. |
| This comprises wholesome food that | |

Source: Parfitt *et al.* (2010)

## 2.7 CAUSES OF GRAIN LOSS

Odeyemi and Daramola (2000) asserts that, in the value chain of maize there are several stages in which maize grains are loss; the factors that lead to grain loss can be group

into, socio-economic, physical, engineering/mechanical and biological. The moisture content of the grains together with the storage temperature constitutes the physical factors such as temperature immensely after the respiratory rate of the stored food. Other physical factors such as relative humidity and pest organisms greatly affect the stored grains. The weather condition in the country is conducive to the survival of such pest while the fluctuation of temperature increases the risk of damaging the viability of the maize grains and other seeds further making it difficult to avoid postharvest losses. Every food to an extent contain some level of water even at storage, the moisture level of maize grains especially at storage largely affects the rate of degeneration of the grains. It equally exposes the maize grains to pest infestations such as mould and fungi. The pests that infest maize grains at storage are what we refer to as the biological factors. These are living organisms (bacterial, fungi, mice, rats, insects etc.) that feed on the grains as food and often than not contaminate the grains at storage with their urine and droppings including other debris and even toxins they might introduce into the grains. This often alters the taste of the grains which largely affects the market value of the grains. The tools and equipment used in harvesting, the storage structure, structures used in drying and the type of transportation used both on farm and off farm all affect postharvest losses. These factors are referred to as the engineering/mechanical factors. The type of market system, the financial status of the farmer and his/her household and storage are often referred to as the socio-economic factors. The study sought to ascertain the causes of postharvest losses of maize in Ejura-Sekyedumase Municipality of Ashanti Region of

Ghana.

### 2.7.1 Comparison between Losses and Waste

According to FAO (2013) the reduction in the weight and nutritional value of edible food meant for human consumption is referred to as loss food. Unlike food waste, losses occur from the inception of production to the very last stage of the consumer finally consuming the food that is losses occur at every stage of the food chain. Food losses can be attributed to so many factors such as poor technology, logistics and infrastructure, lack of markets, the knowledge and management ability of the actors in the supply chain and insufficient skills (Parfitt *et al.,* 2010).

The leaving of wholesome food to go bad either before it expires or for it to expire or even discarded is referred to as food wastage. It basically occurs not from production but rather from harvesting that is from the retailers to the final consumer. Waste can sometimes include food loss but most often both food loss and waste refers to foods meant for human consumption while any products less than that are not considered as food waste and food loss (Hodges *et al.,* 2011). Food waste could still be managed for consumption and it thus also falls under food loss as it is from food waste that edible products migrates to food loss.

FAO (2011) disclosed that food loss and food waste is when an edible food fails to get to the final consumer for consumption due to several reasons. They further emphasized that the diversion of edible food for other purposes such as fuel generation and feed for animals is also considered as food loss and or food waste.

Below is a typical example on table according to Parfitt *et al.* (2010) of food waste in the food supply chain;

## 2.8 FACTORS CONTRIBUTING TO POSTHARVEST LOSS

The type of produce and the season including the production sites causes variation in the postharvest losses. There are numerous causes of postharvest losses at various stages of the postharvest chain some of which include the invasion by pest, poor handling, and failure to transport to the right markets on time etc. For developed countries the problem of postharvest loss is basically because food is mostly discarded and not eaten for various reasons. The waste of food in developed countries is mostly due to the failure of the developed countries to eat all the edible food at their disposal while that of the under developed and developing countries was their poor postharvest agricultural systems that resulted in the loss of food which could have been salvaged for a better purpose (Hodges *et al*., 2010). There are internal and external factors contributing to postharvest loss.

The following sections describe postharvest losses occurring at various stages of the food supply chain from the farm (harvesting), handling, storage, processing and marketing.

### 2.8.1 Harvesting

The weather conditions and the level of maturity of the crop determine the harvesting of the crop. The primary causes of losses at the harvest stage include; lack of a maturity index for most produce and even the failure to adopt such indices. Poor weather during harvesting time affects the operations and functionality of harvesting machines or human labour and usually increases the moisture content of the harvested products.

NB. Loss is also caused by employment of improper harvesting methods such as: untimely harvest, poor harvesting tools, and equipment, poor handle of produce and bad harvesting containers.



### 2.8.2 Transportation

Primary challenges in the transportation stage of the supply chain include: poor road network linking farms and farming communities to market centres, inappropriate transport vehicles and for those produce that require refrigeration even during transport never get it. The problem of poor roads has been outstanding including the suitable types of vehicles to use in transporting the produce especially perishable once. This is however very important for both local and international markets as it affects the quality of the produce either directly or indirectly in different ways. Even though some individuals and groups have been able to acquire some suitable vehicles they have not been able to fix the poor road conditions in their areas therefore leading to the same postharvest losses (Kader, 2002).

### 2.8.3 Storage

The lack of proper and adequate storage facilities contribute largely to postharvest losses (World Bank, 2011). There are currently very few warehouses, hermetic bins, silos and granaries even with that the level of standards in these storage facilities are rather but poor as most of them are poorly kept and even those which were properly kept are still inadequate in controlling the humidity and temperature which are very necessary in controlling diseases and pest in these warehouses (Cairns *et al.*, 2013).

The effect of pest directly affects the quality and quantity of the stored food and might even affect the warehouse (Suleiman and Rosentrater, 2015).

### 2.8.4 Packaging and Labeling

Most often than not after harvesting on the farm the fresh produce are sent to a packaging house or distribution centre for packaging labelling and for onward distribution or sale. In developing countries most of the produce especially vegetables are not packaged and even when done is done anyhow and sold in the open market (Hodges, 2013). The sale of produce in the open market exposes the produce to unsuitable conditions which reduces the shelf life of the produce especially if not sold quickly (Kaiya, 2014).

### 2.8.5 Secondary Processing

At the secondary processing stage the food is processed to change in form and sometimes quality as different ingredients are sometimes added. Here foods are sometimes reduced in size and some discarded due to their taste and level of deterioration in quality. It is at this stage that some food is loss during processing or transformation to other forms (Kaiya, 2014). Some causes of postharvest loss in this stage include but not limited to the following; poor processing technologies and equipment, inadequate facilities and infrastructure, and insufficient promotion of processed products (Kaiya, 2014).

## 2.9 BIOLOGICAL CAUSES

Another cause of postharvest loss is biological causes which basically have to do with the physiological and morphological disorders that food goes through especially when fresh (Kaiya, 2014). Some of the biological causes of postharvest losses include; ethylene production and action change in composition of food, water stress, mechanical injuries, pathological breakdown and respiratory rate (Kaiya, 2014). Biological factors are however affected largely by environmental conditions such as; humidity, atmospheric pressure, temperature and air velocity and other sanitation procedures (Kader, 2002; Kitimoja and Gorny, 1999).

Factors outside of the food supply chain can cause significant postharvest loss. These factors can be grouped into two primary categories: environmental factors and socioeconomic patterns and trends (Kaiya, 2014).

## 2.10 ENVIRONMENTAL FACTORS

Climatic conditions, including wind, humidity, rainfall, and temperature influence both the quantity and quality of a harvest (Grolleaud, 2002).

### 2.10.1 Temperature

Temperature largely affects perishable produce especially horticultural products as it reduces the life span of the product when temperatures are high as this serves as a catalyst for reactions and activities that would promote a faster deterioration of the farm produce. Lower temperatures seem to reduce the rate of deterioration of the some farm

produce and serves as a catalyst for the deterioration of other farm produce as some such as maize are most likely to mould at lower temperatures due to conditions being favourable for fungi grow but lower temperatures are rather favourable conditions for preserving perishable products such as vegetables and fruits including other horticultural products (Atanda *et al.,* 2011).



### 2.10.2 Humidity

The amount of water vapour surrounding stored food greatly affects the biological activities around the food. It provides conditions favourable for the growth and activities of other living organisms that might be pest to the stored food. The amount of water absorbed or released by stored food is influenced by the relative humidity in the surroundings of the stored food as some foods release water to the atmosphere while others absorb from their surroundings for example; most fresh vegetables and horticultural crops would give out water into the atmosphere when the relative humidity is high and absorb water from their surroundings when the relative humidity is low. There is therefore the need to avoid storing dry food under low relative humidity conditions and fresh foods under high relative humidity conditions (Atanda *et al.,* 2011).

### 2.10.3 Altitude

The altitude generally refers to the height above sea level, this depending on the latitude affects the temperature of a particular location as temperature is expected to drop by $6.5^0$ C for each kilometre in altitude above sea level (Atanda *et al.,* 2011). This implies that

the altitude affects the storage life of food as it directly affects temperature in such surrounds (FAO, 1983).

### 2.10.4 Time

Time is a natural factor that affects postharvest losses as the longer food is stored the more it deteriorates in both quality and quantity. Time affects food right from the time of harvest as when harvesting is delayed food is loss. It affects the food chain at every stage as a delay in every stage of the food chain could cause a loss in either the quality or quantity of food.

## 2.11 SOCIO-ECONOMIC FACTORS

Social trend such as urbanization has driven more and more people from rural area to large cities, resulting in a high demand for food products at urban centres, increasing the need for more efficient and extended food supply chains (Parfitt *et al*., 2010). Other socio-economic factors are linked with grain importation which can introduce new insect species, hence posing a very significant problem. Not only is the imported grain at risk, but the native grain as well. For example, in 1980, the introduction of a new insect species to Africa along with grain importation created weight losses of up to 30% in just 3-6 months of storage (Boxall, 2001).

### 2.11.1 Consumption

The world over there is usually a more than 116 million tons of maize consumed annually of which Africa consumes only 30% (Raouf, 2011). In the African continent 95% of maize is used as food but for the Southern and Eastern parts which used 85% of their maize as food (Suleiman *et al*., 2013). In many parts of the world maize is used for

other purposes especially animal feed (Raouf, 2011). The type of maize mostly consumed in Africa is the white maize which could be prepared into several delicious dishes ranging from roasting the fresh maize or boiling it the way it when its freshly harvested to grinding it for preparing porridge, "T.Z and Banku" (Ennin et al., 1999). The white maize is widely consumed here in Africa while maize serve as the main staple crop here in most African countries. The yellow maize is mostly used for animal feed especially poultry due to its ability to give the yolk of the egg the yellow colour (Suleiman *et al*., 2013).

## 2.12 MAIZE PRODUCTION IN AFRICAN AND ITS ASSOCIATED POSTHARVEST LOSSES

Maize has been the dominant food crop in Africa since its introduction in the fifteen hundred (1500) (Suleiman *et al*., 2013). The grains are rich in calories, vitamin E, A and C, protein and dietary fibre which are all essential for the wellbeing of human beings and even animals (Raouf, 2011). The United States of America is the leading producer of maize in the world as they contribute 42% of the world's total maize production while the entire African continent contributes just 6.5% to the total quantity of maize produced globally (De Groote *et al*., 2013). In Africa, Nigeria is the leading producer of maize with a total production of approximately 8 million tons with South Africa being the second (Verheye, 2010). This has led to famine in cases of poor rainfall as maize production is if not completely rain fed. Aside this African continent has almost always fallen short of supply as the demand for maize on the continent exceeds that of its demand and therefore the continent imports close to 28% of the maize it requires to try to meet the demand by the countries on the continent

(Nyoro, 2004).

The level of postharvest losses in most African countries is alarming as in some countries about half the crops produced are loss especially root and tuber crops, vegetables and fruits and other perishable crops to mention but a few (FAO, 2004). For grain cereals it is the same but less due to the nature of the grains as about 25% is loss after harvest. In most of the East African countries the postharvest losses are largely due to food spoilage and wastage which leads to the countries losing close to a hundred million dollars annually (FAO, 2004).

### 2.12.1 Disease Incidence and Constraints

Various species of stem borers rank as the most devastating maize pests in SSA (Tilman, 2002). They can cause 20-40% losses during cultivation and 30-90% losses postharvest and during storage (Odendo *et al*. 2001). Other pests in SSA include ear borers, armyworms, cutworms, grain moths, beetles, weevils, grain borers, rootworms, and white grubs. The parasitic Striga weed is another maize pest. In fact, weed-related yield losses ranging from 65 to 92% have been recorded in the Nigerian savannah (Odendo *et al*. 2001).

Maize diseases in SSA include downy mildew, rust, leaf blight, stalk and ear rots, leaf spot, and maize streak virus (MSV). Maize does not tolerate drought well and the grain can rot during storage in tropical climates. A lack of sunshine and nitrogen can reduce the production potential of the crop (Odendo, 2001).

### 2.12.2 Technologies and Practices to Reduce Postharvest Losses

There are many examples of promising practices. These range from training in improved handling and storage hygiene to the use of hermetically sealed bags and household metallic silos, and are supported by enhancing the technical capabilities of local

tinsmiths in silo construction. (World Bank, 2011). The choice of technology package depends on circumstances, such as the scale of production, crop type, prevailing climatic conditions, and the farmers‟ affordability and willingness to pay (which are linked to social, cultural and economic implications of adoption).



The commonest strategy for reducing postharvest loss is simple and basic strategy of reducing postharvest food losses for any type of commodity. A systematic analysis of each commodity production and handling system is the logical first step in identifying an appropriate strategy for reducing postharvest losses (Bell *et al.,* 1999; Kitinoja and Gorny, 1999).

Table 2.4: Strategies of reducing postharvest food losses in cereal grains

| Stage in the food system | Description and strategy |
|---|---|
| Harvesting | In tropical countries in general, most grains have a single annual harvesting season, although in bimodal rainfall areas there may be two harvests (e.g., Ghana and Uganda). African producers harvest grain crops once the grain reaches physiological maturity (moisture content is 20-30%) (FAO, World Bank, 2011). At this stage the grain is very susceptible to pest attacks. Poor farmers sometimes harvest crops too early due to food deficiency or the desperate need for cash. In this way, the food incurs a loss in nutritional and economic value, and may get wasted if it is not suitable for consumption. Quality cannot be improved after harvest, only maintained; therefore, it is important to harvest at the proper maturity stage and at peak quality. |
| Drying | Most farmers in Africa, both small and large, rely almost exclusively on natural drying of crops by combining sunshine and movement of atmospheric air through the product; consequently, damp weather at harvest time can be a serious cause of postharvest losses (De Lima, 1982). Grains should be dried in such a manner that damage to the grain is minimized and moisture levels are lower than those required to support mould growth during storage (usually below 13-15%). This is necessary to prevent further growth of fungal species that may be present on fresh grains. |
| Threshing/s | For some grains, particularly millet and sorghum, threshing may be delayed for several months after harvest and the unthreshed crop stored in open cribs. In the case of maize, the grain may be stored on the cob with or without sheathing leaves for some months, or the cobs may be shelled helling and grain stored. Some |

machinery suitable for small small-scale operation exists such as: maize shellers; Rice mechanical threshers which are actively being promoted by the International Rice Research Institute (IRRI).

Usually done prior to storage or marketing if the grain is to be sold directly. For the majority of the smallholder, this process is done manually. It is relatively ineffective from a commercial perspective, since

Winnow/cl grain purchased from smallholders frequently requires screening to eaning remove stones, sand, and extraneous organic matter. There is little incentive for smallholders to provide well-cleaned grain for marketing; As a result, profits from sales are limited.

Postharvest losses at storage are associated with both poor storage conditions and lack of storage capacity. It is important that stores be constructed in such a way as to provide:-dry, well-vented conditions

On-farm allowing further drying in case of limited opportunities for complete storage drying prior to storage;-protection from rain and drainage of ground water; and -protection from entry of rodents and birds and minimum temperature fluctuations

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Source: Bell *et al.*, 1999; Kitinoja and Gorny, 1999

**2.12.3 The Maize Economy of Ghana**

Maize has been cultivated in Ghana for several hundreds of years. According to Morris *et al.*, (1999) since the introduction of maize in the 16$^{th}$ century, it has established itself as an important food crop in the country. In no time, maize also attracted the attention of commercial farmers, even though it never achieved economic importance as compared to traditional plantation crops such as, oil palm and cocoa. Over time, the eroding profitability of many plantation crops (attributable mainly of increasing disease problems in cocoa, deforestation and natural resource degradation, and falling world commodity prices) serve to strengthen interest in commercial food crop, including maize (Morris *et al.*, 1999). Maize is currently Ghana's most important crop. It is grown by the vast majority of rural households in almost all the parts of the country except for the Sudan Savannah Zone of the North (Al-Hassan and Jatoe, 2002).

### 2.12.4 Production trend of maize in Ghana

According to MoFA- SRID (2009), maize area cultivated annually in Ghana averages about 846,300 hectares. In Ghana maize is intercropped with other crops, particularly in the coastal savannah and the forest zones, so planting densities are generally low. Average grain yields of maize are modest when expressed per unit land area, averaging less than 2 t/ ha. Total annual maize production is currently over 1,470,000 metric tonnes (MoFA SRID, 2009). The two key determinants of maize production (area planted and yield) have increased over the years, although the upward trends have been characterized by high year- to-year variability typical of rain fed crops

(MoFA SRID 2009).

## 3.0 MATERIALS AND METHODS

### 3.1 THEORETICAL FRAMEWORK

The amount of postharvest loses that occurs (whether through on-farm loses or loses along the chain during transportation, storage and processing) are influenced by some economic and farm-specific factors.

This is expressed in a linear function with *k* explanatory variables to describe the behaviour of y :$\beta_1 X_1 + \beta_2 X_2 + .....+ \beta_k X_k$ so that

$y = \beta_1 X_1 + \beta_2 X_2 + ...+ \beta_k X_k + \varepsilon(\varepsilon_1.....\varepsilon_k)$where $\varepsilon(\varepsilon_1.....\varepsilon_k)$ denotes the error of the specification. Given a sample of $n^{th}$ maize farmers, the amount of postharvest lose (y) can be expressed as $y = X\beta + \varepsilon$ where $\beta$ $(\beta_1,\beta_2.....\beta_k)$'is the vector of unknown parameters, and y and x contain all the observations of the dependent and the independent variables respectively such that

$y_i = \beta_0 + \sum_{i}^{n} \beta_i X_i + ....+ \beta_t$ where X is the vector of independent

$i \neq j$

variables and y is the vector of dependent variables

## 3.2 EXPERIMENTAL SITE

The research was conducted in some of the selected communities in Ejura-Sekyedumasi municipality specifically Dromankuma, Kasei, Kyenkyenkura, Bemi, Sekyedumase, Drobon, Dejau, Teacherkrom, Ejura and Babaso. These communities served as representations of the situation among maize farmers in the municipality since they are well known as high maize producing areas even though maize is produced in all the communities in the study area (Ejura-Sekyedumasi) and Ejura-

Sekyedumasi is well noted for its high maize production in the whole country

### 3.2.1 Experimental Design

This study was conducted in two parts. The first part consisted of a field survey of maize farmers and marketers. The second part of the study consisted of a field experiment on maize produce from harvesting through the various stages of postharvest handling (harvesting, threshing, shelling, winnowing, transportation drying and storage). For harvesting, selected farmers were allowed to harvest 0.625 hectares of their farm after which the researcher re-harvested the same area. The quantity re-harvested per farm was recorded and average quantities were computed as postharvest loss at that stage. Similarly, farmers were allowed to thresh, shell and winnow their harvested maize. Before this activity, tarpaulins were spread on the field to allow for easy gathering of the chaff and left-overs after threshing, shelling and winnowing. The researcher then gathered chaff and left-overs and re-winnowed it. Quantities of maize obtained were recorded and average quantities were computed to represent postharvest loss at that stage.

Furthermore, during the transportation stage, the difference in weight of bags of maize during loading and offloading were recorded and the overall mean of weight loss estimated as the postharvest during harvesting. About 20 bags of maize out of a truckload of 200 bags headed for Takoradi (386 km away from Ejura) were identified with tags and their weights were recorded before loading and after offloading at the final destination.

Similar approaches were adopted for estimating losses during the drying and storage stages. Weights of bags before and after drying were recorded and the average weights difference derived as postharvest loss. Drying took place for six days after which farmers were allowed to bag the dried maize for re-weighing. Regarding storage, parameters like temperature, relative humidity and moisture content was taken into consideration before weighing and storage. Bags of maize were allowed to store for three months with measurements taken after every two weeks. The overall weight loss after the end of the three months was summed as the postharvest loss at the storage stage. (Appendix Two).

### 3.3 STUDY AREA

The study was carried out in Ejura-Sekyedumase Municipality of Ashanti Region because of the mass production and marketing of maize in that area. The people of the area are predominantly farmers with keen interest in arable crops in general and maize in particular. Ejura-Sekyedumase is the second highest producer of maize after Techiman in the Brong Ahafo Region of Ghana making it a preferred study area.

### 3.3.1 Location and Size

Ejura-Sekyedumase Municipality was carved out of the former Sekyere and Offinso districts and was thus created as a result of the implementation of the decentralization programme on 29th November, 1988. The district was established by a Legislative Instrument, PNDC L.I 1400, 1988. The municipality is located within Longitudes

1°5W and 1°39' W and Latitudes 7°9' N and 7°36'N. It has a large land size of about 1,782.2sq.km. (690.781sq.miles) and is the fifth largest of the 27 districts in Ashanti Region. It constitutes about 7.3% of the region's total land area with about one third of its land area lying in the Afram Plains. With the creation of new districts, the Ejura Sekyedumase Municipality, located in the Northern part of the Ashanti Region, now shares borders with Atebubu-Amantin District in the North-West, Mampong Municipality in the East, Sekyere South District in the South and the Offinso Municipality in the West.

### 3.3.2 Population Size, Structure and Composition

The population of the municipality was 85,446 which represent 1.8% of the entire population of the Ashanti region according to the 2010 Population and Housing Census. The municipality has its population slightly favouring males to females as the males constituted 50.2% while the females constituted 49.8%. About 49.7% of the municipal population live in rural areas with 41.1% of the municipal population being youthful.

### 3.3.3 The Economy of Ejura-Sekyedumase Municipality

#### 3.3.3.1 The agricultural sector

Agriculture is the leading sector in terms of employment and income generation. The sector employs about 69.7 percent of the Municipality's population. In view of this, it is important to promote the agricultural sector to spearhead economic growth for the Municipality. It serves as the main source of livelihood for most people in the Municipality. The Agriculture sector of the Municipality includes both crop production and livestock rearing. Several types of crops are cultivated in the Municipality. Prominent among them are maize, yam, beans, rice, plantain, cassava and groundnuts, to mention but a few. Crops grown are mostly for subsistence purposes. However, crops such as maize, beans and watermelon are cultivated mainly for commercial purpose.

#### 3.3.3.2 Service sector

The service sector is the most developed sector of the Municipality in terms of economic activities. The types of services provided in the Municipality include Petty Trading, Hair Dressing/Tailoring, Driving, Communication Services, Clerical Work and Pharmaceutical Services. Petty Trading and Hairdressing/Tailoring outnumber the rest of the service activities in the Municipality.

#### 3.3.3.3 The industrial sector

The main reason for the promotion of the Industrial Sector in the Municipality is to transform raw materials into processed goods in order to add value to the produce, create employment and promote private sector competitiveness in the Municipality. The main types of industries in the Municipality are manufacturing and agro-based industries. The agro-based industry comprises palm oil production, rice, corn and flour milling, and

mushroom cultivation. The manufacturing industries include saw milling, carpentry, bakery, pottery and blacksmithing.

### 3.3.3.4 Aesthetic features

The Municipality has some sites of historic and aesthetic importance. These aesthetic features are potentials for tourism development that could improve the quality of life of the local people. The following are potential tourism sites that could change the fortunes of the Municipality because of their economic importance:

- The Pru Shelter at Ebuom, the Awura and the Abirimasu Forest Reserves.
- The Kogyae Strict Nature Reserve is the only potential tourist attraction that houses Buffalos, Waterbucks, Water Hogs, Red River Hogs, Black Dingos, etc.
- Striking landscape like naturally-made "Oware" and bridge at Anyinasu and Hiawoanwu respectively
- Waterfalls and rapids at Kasei
- Deep well along a portion of Kyerede stream at Drobon

## 3.4 TARGET POPULATION AND SAMPLE SIZE

The study focused mainly on maize producers/farmers and some marketers in the Ejura-Sekyedumase Municipality**,** taking 120 respondents of farmers/producers and 50 marketers A total of 170 respondents in all were sampled from ten communities in the Ejura-Sekyedumase Municipality of Ashanti Region of Ghana, namely,

Dromankuma, Kasei, Kyenkyenkura, Bemi, Sekyedumase, Drobon, Dejau,

Teacherkrom, Ejura and Babaso.

### 3.5 SAMPLING TECHNIQUES

Purposive sampling technique was used to select ten maize communities in the municipality. One hundred and twenty maize farmers or producers and fifty marketers were randomly selected for the study.

### 3.6 TYPE AND SOURCES OF DATA

Primary data was mainly used for this study. Data elicited from respondents were supported with secondary data from published journals, and other professional literature.

### 3.7 METHOD OF DATA COLLECTION

The information was obtained through structured and unstructured questionnaires, by means of personal interviews and focused group discussions. The focused group discussions enabled an in-depth study of the situation, and this followed by the personal interviews to enable a platform for data analysis

The questionnaire was designed to collect information on demographic and non-demographic variables. The demographic variables include age of farmers, sex, major occupation among others while the non-demographic variable include type of farming operations, problems faced by the farmers in the course of harvesting and postharvest handling of the produce.

### 3.8 METHOD OF DATA ANALYSIS

The Statistical Package for Social Science (SPSS) Version 16 and Microsoft Excel was used to analyse data collected from the field survey complied and collated from the study. Descriptive and inferential statistics were used to arrive at conclusions.

Cross-tabulations were used to establish relationships between respondents' ages and their educational status and also the postharvest loss and the places of storage. The age of respondents and their educational status have the ability to influence production levels and their ability to minimise postharvest losses. The place of storage also has the ability to influence the rate of postharvest losses. A chi-square test of significance was used to test the degree of significance between postharvest loss and the place of storage.

The ordinary least square method of regression analysis was also used with the functional forms of semi log and double log to estimate the relationship between the dependent variable and the set of explanatory variables. The best-fit equator were selected based on the goodness of fit as indicated by the coefficient of determination ($R^2$) and adjusted R square ($R^{-2}$), the signs of regression coefficients, the overall significance of the model as indicated by the F – value and the statistical significance of individual coefficients as indicated by the t -test.

The implicit model is specified as:

$Y = F(x_1, x_2, x_3, x_4, x_5, x_6, x_7, e_1)$

Where

Y = Average loss of yield of maize in kilogram

X1= Gender

X2 = Marital status

X3 = Level of education

X4 = Level of output

X5= Duration of storage

X6 = Type of storage facilities

X7 = Frequency of sales ei =

Error term



The explicit statements of semi log and the double log are presented in equations (2) and (3), respectively.

Semi log

Logy = b0 + b1X1 + b2X2 + b3X3 + b4X4 + b5X5 + b6X6 + b7X7 + ei…… (2)

Double log

Logy = logb0 + b1logX1+ b2logX2 + b3logX3 + b4logX4 + b5logX5 + b6logX6 + b7logX7 + ei …….. (3)

Where:

b0 = intercept b1 – b7 are the regression coefficients of X1 – X8 respectively.

The perceived constraints to the production and marketing of maize were identified and ranked by respondents in order of importance. Kendall's Coefficient of Concordance (w) was employed to measure the extent of agreement of the respondents' rankings. Kendall's coefficient of concordance is a measure of the agreement among judges who are assessing a given set of objects. It can be computed in several ways but for this study:

$$w = \frac{12S}{3} \quad \text{And} \quad S = \sum_{i=1}^{n}(Ri - \bar{R})^2$$

$$\frac{}{p\,(n\,\square n)\square pT}$$

Where p = number of judges; n = number of problems ranked; S = sum of squared deviation; $R_i$=sum of ranks; R= mean sum of ranks and T= error term when there is tie.



- $w$ =1 represents a perfect agreement.
- $w$ = 0 represents no agreement.
- Intermediate values of $w$ indicate a greater or lesser degree of unanimity among the various responses.
- The Friedman's chi-square: $X^2 = p\,(n - 1)\,w$ was used to test the conformability of the respondents' rankings.

## 4.0 RESULTS

This chapter presents the results of the field survey leading toward answering the research questions and achieving the stated specific research objectives. It begins with detailed presentation of the results obtained from the field survey. It follows with detailed analysis of the results by investigating some other socio-economic characteristics of respondents, the modes of handling of maize from harvest to the sales point, the factors influencing postharvest loses of maize at each stage of handling and finally the constraints associated with postharvest handling of maize. It begins with the demographic characteristics such as gender, age, marital status, educational background, economic activities, etc. These characteristics will show the various classes of respondents and how the classes influence the perception of their views, choices, preferences, etc. associated with the topic. It contains also, results from the field experiment on the various postharvest handling stages that affect total postharvest loss.

## 4.1 FIELD SURVEY

A total of 170 respondents (farmers and marketers) were sampled from ten communities in the Ejura-Sekyedumase Municipality of Ashanti Region of Ghana, namely, Dromankuma, Kasei, Kyenkyenkura, Bemi, Sekyedumase, Drobon, Dejau, Teacherkrom, Ejura and Babaso. Out of this number, the return rate of the completed questionnaire was (98%). One hundred and sixty six (166) respondents complete the questionnaires. The return rate of the producers was high since respondents were subjected to interview with a semi-structured (Appendix One)

## 4.2 DEMOGRAPHIC AND SOCIAL- ECONOMIC CHARACTERISTICS OF RESPONDENTS

### 4.2.1 Gender Distributions of Respondents

Figure 4.1 shows the gender distribution and marital status of the selected maize farmers in the Ejura-Sekyedumase Municipality. Whilst 56% Represents Male Farmers, 44% Were Females.

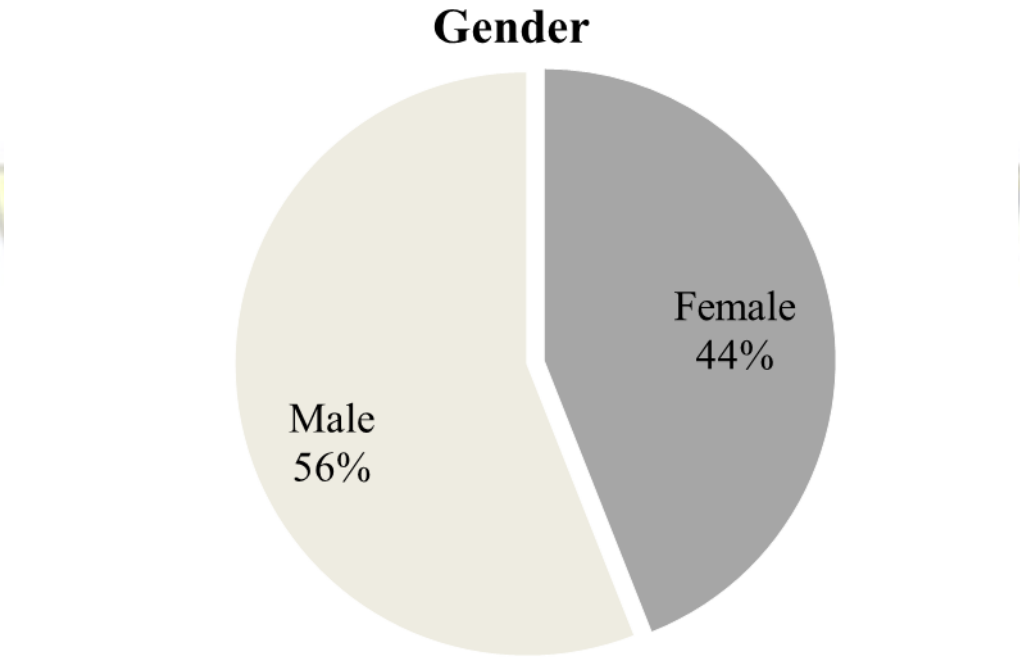

Figure 4.1 Gender distributions of respondents

### 4.2.2 Marital Status of Respondents

From figure 4.2, it can be seen that majority of the respondents were married as about 64% represented those who were married whilst only 36% were single.

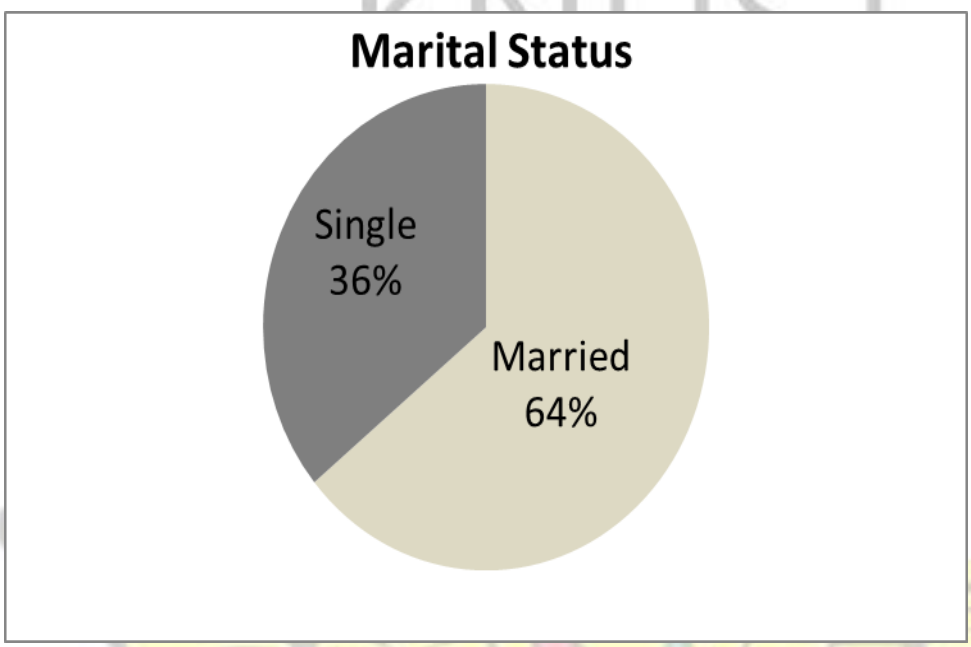


Figure 4.2 Marital status of respondents

### 4.2.2 Educational Background and Age Distribution of Respondents

Table 4.1 below shows the educational background and age distribution of respondents. On the educational background, only 31% of the respondents have not been educated at all. The rest have had formal education ranging from primary to tertiary. Majority of the respondents representing 33% have schooled up to Junior High School whilst only 13% have had tertiary education who are mostly teachers by profession.

Regarding age distribution, it can be seen that respondents were cut across all the age categories ranging from below 20 years to above 60 years. Both the young and the old

are engaged in maize farming in the Ejura-Sekyedumasi Municipality but majority representing 36% are between the ages of 30 and 39 with minority below age 20 representing only 2%.

Table 4.1: Educational Background and Age Distribution of Respondents

| Category | Frequency | Percent (%) |
|---|---|---|
| Educational Background | | |
| Primary | 41 | 25 |
| J H S | 33 | 20 |
| S H S | 9 | 5 |
| Tertiary | 13 | 8 |
| None | 70 | 42 |
| Total | 166 | 100 |
| Grouped age | | |
| Below 20 Years | 2 | 1 |
| 20-29 Years | 11 | 7 |
| 30-39 Years | 36 | 22 |
| 40-49 Years | 35 | 21 |
| 50-59 Years | 50 | 30 |
| Above 60 Years | 32 | 19 |
| Total | 166 | 100 |

Table 4.2: Cross-tabulation of the Age of the Respondents and their Educational Status.

| Age of Respond Ents | Educational Status | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | None | | Primary | | JHS | | SHS | | Tertiary | | Total | |
| | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % | Freq | % |
| Below 20 | 0 | 0 | 2 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 2 | 2 |
| 20-29 | 0 | 0 | 11 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 11 | 11 |

| | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 30-39 | 0 | 0 | 1 | 3 | 33 | 92 | 2 | 5 | 0 | 0 | 36 | 36 |
| 40-49 | 3 | 13 | 0 | 0 | 0 | 0 | 7 | 30 | 13 | 13 | 23 | 23 |
| 50-59 | 13 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 13 | 13 |
| Above 60 | 15 | 100 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 100 | 15 | 15 |
| Total | 31 | 31 | 14 | 14 | 33 | 33 | 9 | 9 | 13 | 13 | 100 | 100 |

### 4.2.3 Income Levels of Respondents

Table 4.3: below summarizes the income levels of respondents from the maize they cultivate as well as from other income sources. It gives the average income of farmers and as well the minimum and maximum income with the standard deviation among respondent's income levels.

Table 4.3: Income levels of farmers (GHC) earned in 2014

| Income Source | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Total Income from Maize | 96 | 200 | 27750 | 4215.78 | 4515.08 |
| Total income from other | 82 | 400 | 15500 | 2133.68 | 3053.63 |

Source: Field Survey, 2015

The average income for the respondents obtained from maize in the 2014 farming years is GHC 4,215.78 (Table 4.3). The minimum income is GHC 200 whilst the maximum income GHC 27750 with a standard deviation of GHC 4515.08. Furthermore, the average of respondents who engage in other economic activities other than from maize farming is GHC 2133.68. Also, the minimum and maximum incomes earned from these other economic activities are GHC 400 and GHC 15500 respectively. The degree of variation among respondent is GHC 3053.63.

### 4.2.4 Other Income Earning Activities

Figure 4.3 shows the proportions of farmers engaged in other income generating activities other than farming and the nature of these activities. It can be observed that majority of the respondents representing 83% are engaged in other income earning activities other than farming. Only 17% are solely engage in farming.

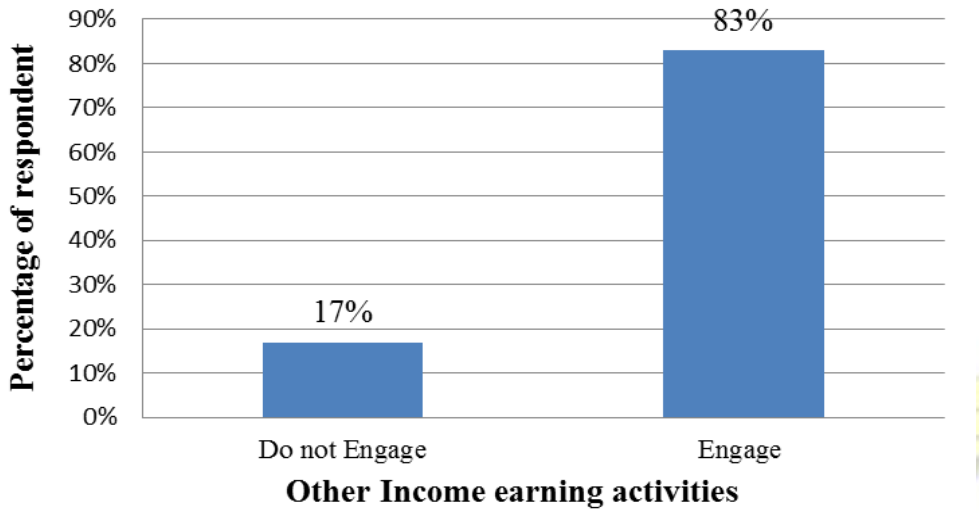


Figure 4.3: Other income earning activities

### 4.2.5 Nature of Other Income Earning

From figure 4.4, 24% respondents who engaged in other income earning activities, 46% were traders with 30% as teachers. The rest are engaged in other activities such as driving, mechanic activities, hair dressing, and cleaning activities among others.

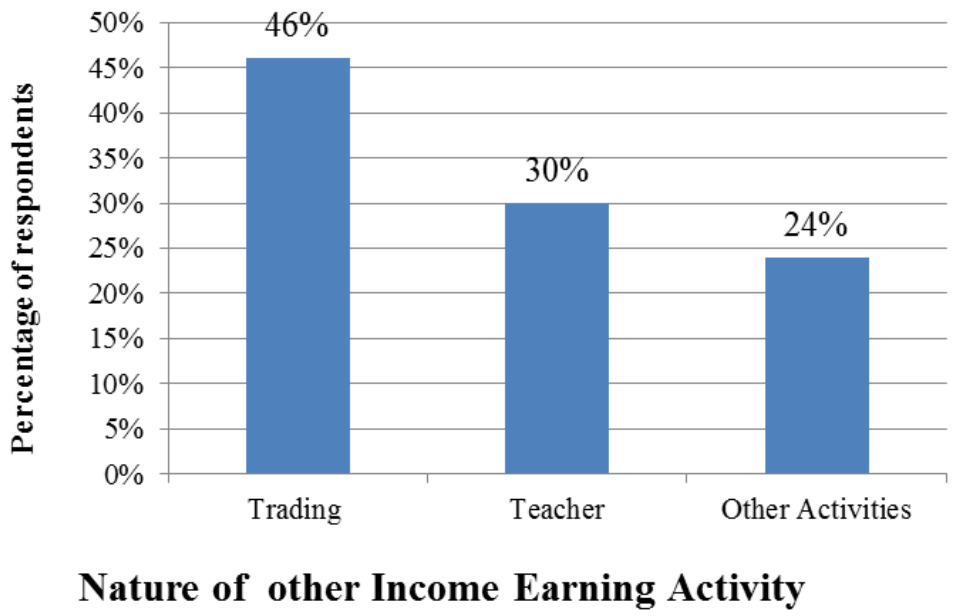


Figure 4.4 Nature of other Income Earning Activities

### 4.3 TYPE OF CROPPING, PLACE OF STORAGE AND EXPERIENCE OF POSTHARVEST LOSS

Table 4.4 below represents the proportions of farmers engage in intercropping, the places they store their maize after harvest and their experience in postharvest losses. It will later be established in this chapter how these factors affect postharvest losses of maize but the focus here is just to identity their various frequencies.

Table 4.4: Intercropping, Place of Storage and Experience of Postharvest Loss

| Category | Frequency | Percent (%) |
|---|---|---|
| Intercropping | | |
| Yes | 60 | 36 |
| No | 106 | 64 |
| Total | 166 | 100 |
| Place of storage of Maize | | |
| Traditional Storage | 90 | 54 |
| Warehouse | 28 | 17 |
| Other Places of Storage | 48 | 29 |

| | | |
|---|---|---|
| Total | 166 | 100 |
| Experience of postharvest loss | | |
| Yes | 150 | 90 |
| No | 16 | 10 |
| Total | 100 | 100 |

Table 4.5: Cross-tabulation of Storage and Postharvest Losses

| Place of Storage | Postharvest Losses | | | | Total | |
|---|---|---|---|---|---|---|
| | Yes | | No | | | |
| | Freq | % | Freq | % | Freq | % |
| Traditional Storage | 38 | 100 | 0 | 0 | 38 | 100 |
| Other places | 25 | 74 | 9 | 26 | 34 | 100 |
| Total | 91 | 91 | 9 | 9 | 100 | 100 |

Table 4.6: Chi-Square for significance between Place of Storage and Postharvest Losses

| | Value | df | Asymp. Sig. (2-sided) |
|---|---|---|---|
| Pearson Chi-Square | 19.198[a] | 2 | .000 |
| Likelihood Ratio | 21.209 | 2 | .000 |
| Linear-by-Linear Association | 14.741 | 1 | .000 |
| N of Valid Cases | 100 | | |

1. 3 cells (50.0%) have expected count less than 5. The minimum expected count is 2.52.

About 74% of respondents indicated that they do not `practice intercropping when it comes to maize farming with only 26% engage in intercropping. About 38% store their maize traditionally after harvest whilst 28% have access to warehouses and store their maize. Also, up to 34% of farmers store their maize by other means such as storing it in their rooms, verandas, kitchens as well as in the open whilst covering with tarpaulins. About 91% of maize farmers admitted they experience various degrees of postharvest losses. Only 9% do not experience postharvest losses.

### 4.3.1 Farm Size Allocated to Maize Farming and the Variety of Maize Cultivated by Farmers

Table 4.7 below shows the average farm size allocated to maize cultivation by farmers in 2014.



Table 4.7: Average Farm Size Allocated to Maize Cultivation in Acres

| | N | Minimum | Maximum | Mean | Std. Deviation | Variance |
|---|---|---|---|---|---|---|
| | Statistic | Statistic | Statistic | Statistic | Statistic | Statistic |
| Farm Size | 100 | 1 | 19 | 5.15 | 3.72 | 13.86 |

From table 4.7, it can be seen that the average farm size farmers allocate to maize cultivation is about 5.15 acres. The least farm size a farmer will allocate to maize farming is 1 acre whilst the maximum farm size is 19 acres.

Table 4.8: Variety of Maize Cultivated by Farmers

| Maize Variety | Frequency | Percentage (%) |
|---|---|---|
| Obaatanpa | 49 | 29.50 |
| Okomasa | 9 | 5.40 |
| Aburontia | 11 | 6.60 |
| Panaa | 6 | 3.60 |
| Dobidi | 5 | 3.00 |
| Aburohoma | 86 | 51.80 |
| Total | 166 | 100.00 |

Table 4.9 shows a multiple response analysis of the variety of maize cultivated by farmers in Ejura-sekyedumasi. About 86 farmers representing 86% of the respondents cultivate the Aburohoma variety whilst 49% cultivate Obaatanpa. The least cultivated variety is Dobidi as only 5% cultivate the variety.



Table 4.9: Average Yield Obtained from the Various Varieties Cultivated in Bags (120kg)

| Maize Variety | N Statistic | Minimum Statistic | Maximum Statistic | Mean Statistic | Std. Deviation Statistic |
|---|---|---|---|---|---|
| Obaatanpa | 49 | 4 | 135 | 20.46 | 23.29 |
| Okomasa | 9 | 4 | 21 | 11.67 | 5.39 |
| Aburontia | 11 | 5 | 18 | 9.77 | 5.13 |
| Panaa | 6 | 6 | 23 | 11.33 | 6.59 |
| Dobidi | 5 | 5 | 18 | 11 | 4.95 |
| Aburohoma | 86 | 7 | 159 | 36.28 | 30.59 |

Table 4.9 above shows the average yield of the various maize varieties cultivated. Aburohoma being the most cultivated variety has an average yield of 36.28 bags with a minimum yield of 7 bags and a maximum yield of 159 bags depending on the area of land cultivated. The standard deviation is around 30.95 bags which are below the average yield. Obaatanpa also has an average yield of 20.46 bags with minimum yield of 4 bags and maximum yield of 134 bags. The least variety obtained by farmers in terms of yield is Aburontia with an average yield of 9.77 bags followed by Dobidi with an average yield of 11 bags.

### 4.3.2 Postharvest Activities of Maize from Harvest to Final Use. (Field survey)

Table 4.10 below shows the postharvest activities of maize with their various proportions. The activities range from harvest to final use of the product.

Table 4.10 Postharvest Activities on Maize in Bags (100kg)

| Nature of Activity | N | Minimum | Maximum | Mean |
|---|---|---|---|---|
| Total Harvest | 100 | 4 | 165 | 45.50 |
| Amount sold immediately after harvest | 100 | 0 | 142 | 23.89 |
| Amount stored | 100 | 0 | 330 | 23.53 |
| Duration of storage (in months) | 83 | 1 | 6 | 2.36 |
| Amount consumed | 100 | 0 | 5 | 2.00 |
| Amount given as gifts and in-kind payments | 100 | 0 | 5 | 1.05 |
| Amount reserved for planting | 100 | 0 | 5 | 1.37 |

From Table 4.10, it is seen that the average quantity of maize harvested is 45.50 bags varying from a minimum of 4 bags to a maximum of 165 bags depending on the scale of production. Also, respondents sell an average of 23.89 bags of maize immediately after harvest out of the 45.50 bags harvested. Similarly, the amount of maize stored after harvest is 23.53 bags. It ranges from a minimum of zero bags to a maximum of 330 bags. However, the duration of storage is very short with an average of 2.36 months and a minimum and maximum period of 1 and 6 months respectively. Also, respondents spent an average of 2 bags and 1.05 bags respectively on their own consumption and given out to people as gift and other in-kind payments for services. These amounts rang from zero bags to 5 bags indicating that some do not store their maize for consumption or given to people as gifts and other in-kind payments. Finally, respondents reserve an average of 1.37 bags for planting in the next farming season. The amount however ranges from zero bags to 5 bags.

### 4.3.3 Levels of postharvest Losses at Each Stage of postharvest Activity from the Field Survey

Table 4.11 below shows postharvest loss at each stage of postharvest activity. It indicates the average yield lost at these stages together with minimum and maximum losses.



Table 4.11: Postharvest Loss per Acre from the survey at Each Stage of postharvest Activity in Bags (100kg)

| Postharvest Activity | N | Minimum | Maximum | Mean | Std. Deviation |
|---|---|---|---|---|---|
| Harvesting | 91 | 0.05 | 1.2 | 0.38 | 0.24 |
| Transportation | 91 | 0 | 0.3 | 0.02 | 0.05 |
| Threshing/Shelling | 91 | 0 | 0.45 | 0.15 | 0.11 |
| Winnowing | 91 | 0 | 0.5 | 0.12 | 0.14 |
| Drying | 91 | 0 | 1 | 0.12 | 0.16 |
| Storage | 91 | 0 | 0.6 | 0.25 | 0.18 |
| Total Loss | | 0.05 | 4.05 | 1.04 | |

From table 4.11 that postharvest losses occurred at every stage of postharvest activities ranging from an average of 0.02 bags to 0.38 bags per acre. From table 4.11, an average of 3.8 bags per acre is lost from the harvesting stage which constitutes the highest loss.

Also, a significant amount of losses ranging from an average of 0.12 bags to 0.15 bags per acre occur at the drying, winnowing and threshing stages.

The least activity where losses occur as indicated earlier is the transportation stage where an average of 0.02 bags per acre is lost.

### 4.3.4 Maize Sales and Nature of Buyers

Table 4.12 below presents a multiple response analysis of farmers on their choice of buyers for their maize produce.

Table 4.12: Sales of Maize and Nature of Buyers

| Nature of Buyer | Responses | |
|---|---|---|
| | N | Percent |
| Final Consumers | 5 | 3.1 |
| Retailers | 16 | 9.9 |
| Wholesalers | 72 | 44.7 |
| Processing Firms | 7 | 4.3 |
| Farmer Organizations | 28 | 17.4 |
| Institutions (NGO, GOV, etc) | 22 | 13.7 |
| Other buyers | 11 | 6.8 |
| Total | 161 | 100 |

About 74% of the respondents indicated they sell their produce to wholesalers (Table 4.2). This is followed by farmer organizations where about 28% indicated they sell their produce to. Respondents who belong to farmer organizations usually sell their maize to these organizations for better prices. The farmer organizations then gather these produce from their members and sell to NGOs mostly the World Food Program and other buyers like poultry farmers. Also, the least buyer types to which farmers sell their produce are final consumers followed by processing firms representing 5.20% and 7.20% respectively.

### 4.3.5 Estimation of Postharvest Loss (field experiment)

Table 4.13 below shows a summary of the outcome of the field experiment conducted through the various postharvest handling stages. Detailed results from the field experiment can be found at the appendix.



Table 4.13 Mean postharvest loss (%) at various stages of postharvest handling.

| | **Handling stages** | | | | | |
|---|---|---|---|---|---|---|
| **Season** | **Harvesting** | **Shelling, threshing and Winn** | **Drying** | **Storage** | **Trans portation** | **Total** |
| Major (%) | 2.2 | **winnwinn**4.5 | 2.5 | 5.3 | 1.7 | 16.20 |
| Minor (%) | 3.7 | 4.0 | 1.6 | 4.5 | 1.1 | 14.90 |
| Total (%) | 5.9 | 8.5 | 4.1 | 9.8 | 2.8 | 31.100 |
| Mean loss per season (%) | 2.95 | 4.25 | 2.05 | 4.90 | 1.40 | 15.55 |

Averagely, the 16.2% of maize was realized as postharvest loss throughout the postharvest handling stages during the major season whereas 14.9% of maize was lost along the postharvest handling stages during the minor season. The total loss per year was 31.1%, implying an average mean of 15.55% of maize loss per season for maize. That is the overall mean loss per season in the study area is 15.5%. On the average, about 2.95% and 4.25% of maize were recorded as loss per season during harvesting and the shelling, threshing and winnowing stages respectively and storage which happened to be the second stage where postharvest loss occurred most in the field survey recorded the highest stage of postharvest loss in the study area. The drying and transportation stages recording the least stages where losses occurred, (2.05% and

1.4% respectively) which is not different from the field survey.

### 4.3.6 Regression Analysis on some Independent Variables Affecting Postharvest Loss (dependent 4.3. variable)

Table 4.14 shows regression analysis of some dependent variable against total average loss per acre.



Table 4.14 Regression analysis of some independent variable against total average loss per acre

| Total loss | Coefficient | Standard error | T | P>\|t\| | [95% Conf. | Interval] |
|---|---|---|---|---|---|---|
| Age | 0.0135 | 0.0139 | 0.96 | 0.338 | -0.0143 | 0.0413 |
| Gender | -0.2964 | 0.2847 | -1.04 | 0.301 | -0.8623 | 0.2695 |
| Marital status | 0.0719 | 0.2587 | 0.28 | 0.782 | -0.4424 | 0.5861 |
| Education | 0.0610** | 0.0268 | 2.27 | 0.025 | 0.0077 | 0.1143 |
| Farm size | -0.0073 | 0.1167 | -0.06 | 0.950 | -0.2393 | 0.2246 |
| Household size | 0.1247** | 0.0619 | 2.02 | 0.047 | 0.0018 | 0.2477 |
| Production length | 0.0653*** | 0.0129 | 5.08 | 0.000 | 0.0397 | 0.0908 |
| Total output | -0.0113 | 0.0117 | -0.97 | 0.335 | -0.0346 | 0.0119 |
| Storage duration | 0.0045** | 0.0018 | 2.58 | 0.012 | 0.0010 | 0.0080 |
| Warehouse | 0.0062 | 0.0307 | 0.20 | 0.841 | -0.0548 | 0.0672 |
| Traditional storage | -1.1368*** | 0.2611 | -4.35 | 0.000 | -1.6559 | -0.6177 |
| Other storage | -0.0317 | 0.2509 | -0.13 | 0.900 | -0.5306 | 0.4672 |
| Constant | 1.3043 | 0.7805 | 1.67 | 0.098 | -0.2472 | 2.8558 |

Number of observations 99 F(12, 86) 10.39
Prob>F 0.0000 R-squared 0.5917 Adjusted R-squared 0.5348

The asterisk indicates the level of significance; ***significant at 1% and **significant at 5%.

### 4.3.7 Constraints Associated with Postharvest Handling of Maize

Table 4.15 below shows constraints associated with postharvest handling of maize.

Respondents were made to rank each constraint with respect to its degree of severity. Below is the frequency distribution of their responses together with their mean ranks and overall ranks.

Table 4.15 Constraints Associated with Postharvest Handling of Maize

| Constraint | Very Severe | Severe | Moderate | Less Severe | Not Severe | Mean Rank | Overall Rank |
|---|---|---|---|---|---|---|---|
| Non-availability of threshing services | 76 | 20 | 1 | 2 | 1 | 1.32 | 2 |
| Lack of storage facilities | 78 | 20 | 2 | 0 | 0 | 1.24 | 1 |
| High transport cost | 45 | 37 | 12 | 5 | 1 | 1.8 | 5 |
| Pests | 18 | 42 | 18 | 17 | 5 | 2.49 | 7 |
| Pilfering | 5 | 15 | 25 | 41 | 14 | 3.44 | 8 |
| Difficulty finding buyers | 72 | 18 | 4 | 3 | 3 | 1.47 | 3 |
| Unstable pricing | 26 | 38 | 27 | 8 | 1 | 2.2 | 6 |
| Harvesting during peak raining season | 61 | 25 | 2 | 9 | 3 | 1.68 | 4 |

Kendall's Coefficient of Concordance =0.417=42%

From table 4.15 above, majority of the constraints identified including non-availability of threshing services, lack of storage facilities, high cost of transportation, difficulty finding buyers and as well having to harvest during raining season are ranked as very severe-severe as their mean ranks ranges between 1 and 2.

Lack of storage facilities for example is ranked first among the other constraints with respect to its severity on respondents with a mean rank of 1.24 followed by nonavailability of threshing services with a mean rank of 1.36. This confirms my earlier

results from table 4.3 where over 54% of the respondents either store their maize traditional or store in other places other than warehouses. Warehouses for storage of maize are very limited in Ejura which the findings reflect very well. Non-availability of threshing services being ranked to be very severe reflects very well on the field as most farmers still use manual method of threshing the maize. This usually brings about huge postharvest losses.

Pilfering and pests are ranked least among all the constraints with mean ranks of 3.44 and 2.49, respectively. Pilfering for example is ranked between moderate to less severe implying that respondents do not really see it as an important constraints compared to others. This reflects very well on the field since farmers are always each other's keeper and hence quarry pilfering (stealing of produce). Also, much attention is not drawn to stealing of maize since in the district.

Finally, a Kendall's Coefficient of Concordance of 0.417 (42%) shows that there is some level of agreements among the ranks of the respondents on the constraints identified. The level of agreement is however not too strong but very significant since the value is very close to 50%. This implies that respondents agree to each other's rankings or rank in a similar manner of about 42%.

# 5.0 DISCUSSION

## 5.1 BACKGROUND INFORMATION OF THE RESPONDENTS

From the results obtained, it can be observed that both males and females actively participate in maize farming in the district. The gender distribution of maize farmers in the area is quite even. Though the male farmers dominate slightly, the percentage of the female farmers is also significant. In many countries, very few women control productive resources such as land, credit, technical services, market outlets and

information (Opio, 2003). It is possibly for this reason that the male farmers are slightly more than their female counterparts.

It was also observed that most of the maize farmers in the area have family responsibilities as majority of them were married and therefore needed to engage in the business to help them cater for their families.

Majority of the maize farmers constituted the youthful population. This is good as the youth constitute the potential labour force. Also for agriculture to contribute to farmers' income and rural development depends on the youth to participate actively. The youth are also characterized by innovative behaviour, minimal risk aversion, less fear of failure, less conservativeness, greater physical strength and greater knowledge acquisition propensity (Umeh and Odom, 2011).

The educational background of the farmers can also influence their production levels and their ability to minimize postharvest losses. Therefore the study decided to crosstabulate the age of the respondents and the educational status (Refer to table 4.2). It was observed that those respondents in their youthful age were also the once with high educational status and this can influence their production levels and they also have the ability to avoid postharvest losses.

Majority of the farmers have had some formal education and this influence their farming activities which contribute to high productivity. This is similar to an observation by Raphael (2008) that farmers with some formal education are often able to obtain high yield than those with low formal education.

### 5.1.1 The Socio-Economic Characteristics of Respondents in the Ejura-Sekyedumase Municipality

#### 5.1.1.1 Other income earning activities

It was observed that majority of the farmers had supplementary sources of income such as trading, teaching and others. Proceeds from maize farming often supplement their salaries whiles the salary also aids in the production process by way of buying farm inputs. It also enabled them to acquire better storage facilities to minimise postharvest losses.

## 5.2 THE MODES OF HANDLING OF MAIZE FROM HARVEST TO THE SALES POINT

### 5.2.1 Cropping System

Maize can usually be intercropped with cassava, plantain and other cereal crops. In basic agricultural science, intercropping has the advantage of maximising a small piece of land. However, the data gathered revealed that, majority of the maize farmers in Ejura do not engage in this habit. Maize is cropped as a sole crop. The few farmers who engaged in intercropping are usually small holder farmers who intercrop the crop with other staple crops for food security. This practice was to offset anticipated losses.

This finding was consistent with the observations of Woomer *et al.* (2004), that intercropping has the advantage of serving as an insurance against total crop failure arising from uncertain rainfall conditions and poor soil fertility. The majority who were not into such practices probably did not realise the advantage of intercropping.

### 5.2.2 Place of Storage

Proper storage of crops plays an important role in ensuring domestic food supply (Thamaga-Chitja *et al.,* 2004). From the data gathered it was observed that majority of the respondents store their maize traditionally due to lack of access to warehouses. Although relatively simple and inexpensive to construct and maintain, traditional storage systems lead to substantial postharvest losses. Maize storage is still a major problem among maize farmers in Ejura. Majority of the farmers normally loose significant incomes through postharvest losses resulting from poor storage systems. Storage facilities do not only offer the opportunity to smooth hunger between staple crop harvests but farmers are possibly able to improve farm incomes by storing crops and selling at premium prices when demand outstrips supply later in the postharvest period (Florkowski & Xi-Ling, 1990 cited in Thamaga-Chitja *et al.,* . 2004). Some few farmers who were basically into large scale farming and could afford to store their crops in warehouses were able to do so. However, there were others who could not afford any storage system and in trying to avoid postharvest losses, sell off their crops immediately after harvest to avoid postharvest loss. It is also likely that farmers who sell their produce from the farm gate will always give the produce out to consumers at a chicken feed. A cross-tabulation of the various storage practices and experience of postharvest losses of the respondents was carried out and the results indicates that majority of the respondents store their products traditionally (refer to

Table 4.4).
It is also observed from the table that all the respondents who store their produce traditionally normally experienced postharvest losses. This is probably due to the lack of technology among the farmers. This results favourably compares with the findings of Adetunji (2007) in a study conducted in Nigeria on the economics of maize storage  A chi-square test for significance between the storage system and postharvest losses was

statistically significant at p≤0.001 (Refer to table 4.5). The choice of storage system will determine whether postharvest losses will occur or not.

### 5.2.3 Farm Size Allocated to Maize Farming and the Variety of Maize Cultivated by Farmers

Majority of the maize farmers in Ejura are small holder farmers cultivating not more than 5 acres. Maize is an important staple food crop in the district and would usually claim higher proportions of farmers' agricultural lands. Majority of these lands are allocated to the cultivation of all kinds of maize varieties. However, the results indicated that the most dominant variety is Aburohoma followed by Obaatanpa, Aburontia, Okomasa, Panaa, and Dobidi respectively. Aburohoma and Obaatanpa are particularly widely cultivated in the district because of their high yielding nature. It was observe that majority of the farmers have their yield falling below the average yield per bag. It was so because majority of the farmers in the district are small holder farmers who cultivate purposely for domestic consumption and they often apply very few inputs resulting in low yields. The results is in keeps with the findings of Morris *et al.* (1999).

### 5.2.4 Income Levels of the Respondents

The amount of income earned from maize farming largely depends on the total land size used for the maize production and the amount of yield gotten from harvest. The quantity of yield may also vary according to weather conditions and agricultural practices adopted (weeding, fertilizer application, planting materials used etc.). It was observed that most maize farmers had extra sources of income apart from the income they obtain from the maize cultivation. However it was also observed that, the average income obtained from maize cultivation was higher than the income obtained from other sources. Those who earned high income from maize cultivation were those who earn

extra income from other sources. This was probably so because those who earn extra income from other sources were able to supplement postharvest losses.

### 5.2.5 Postharvest Activities of Maize from Harvest to Final Use

Several activities normally take place after harvesting the maize before it reaches the final consumer. It was observed that most farmers normally sell off their products immediately after harvest and this is largely due to the need to raise money to cater for various expenses after cultivation. However, the major reason could be the problem of inadequate storage facilities, which normally result in postharvest losses. So in order to avoid postharvest losses often influence these farmers to sell off the products at the farm gate. This situation normally affect the next planting season as most of the farmers always find it difficult to obtain seeds for the next season. Abbas (2014) also observed that maize produce are sold soon after harvesting to cater for household expenditure.

## 5.3 FACTORS INFLUENCING POSTHARVEST LOSS OF MAIZE AT EACH STAGE OF POSTHARVEST HANDLING

### 5.3.1 Levels of Postharvest Losses at Each Stage of Postharvest Activity

It was observed that postharvest losses normally occurred at every stage of postharvest activities. Majority of the losses occur at the harvesting stage followed by storage. The least activity where postharvest losses occur is at the transportation stage. Threshing/ shelling and winnowing stage were observed to have the highest mean loss of 0.98 bags per acre which might be attributed to the inefficiency and ineffectiveness of the technology and equipment's used at this stage. The poor equipment's used coupled with the use of manual and out dated and less efficient technology accounts for the high postharvest losses at this stage together with negligence on the part of those threshing

and winnowing. Most farmers still rely on the manual way of harvesting which often result in high losses. This is in keeping with Abbas (2014) who also found out that smallholder farmers basically winnow, dehull, dry, sort and shell after harvesting. He however also observed that farmers exhibited poor knowledge and skills in post-harvest handling.



Postharvest losses often occur at the storage stage basically due to the lack of warehouses. Storage being the second highest in loss might be due to mould, rodent and other pest infestations which did not just lead to a loss in the quantity but also the quality of the maize grains it had to be winnowed and bad grains including other debris removed from the wholesome ones. It has been observed by Thamaga-Chitja *et al.*, (2004) that quality is an important determination of crop retail prices. This makes effective storage to be crucial to improve agricultural incomes and food security for small scale farmers. Transportation was also another means through which postharvest losses were recorded. According to Kader (2002), poor road network and inappropriate transport vehicles fitted with storage facilities like refrigerators for products that require refrigeration are mainly responsible for postharvest losses. Apart from the road network, postharvest losses emanating from transportation was a bit minimal as compared to the other causes of postharvest losses. This is largely due to the availability of transport services for farmers to convey their produce.

### 5.3.2 Maize Sales and Nature of Buyers

It was observed that the maize farmers often sell their produce to different buyers ranging from final consumers to bigger institutions and organisations like the government and non-governmental organisations and at times wholesalers. Most

farmers prefer to sell to the wholesalers. Some farmers also believe that selling to organisations can offer them better prices.

It was also common to see smallholder farmers selling their produce to final consumers. The large scale farmers prefer the other category of buyers to the final consumers because they are usually not well established buyers and would usually buy small quantities from retailers other than farmers themselves. Processing firms also form part of the least buyers mainly because they buy in large quantities which these individual small holder farmers are unable to meet their demand. Only few farmers who produce in relatively large quantities have access to this market.

## 5.4 FIELD EXPERIMENT RESULTS

### 5.4.1 Estimation of Postharvest Loss (field experiment)

From the results, it is observed that postharvest loss per season normally emanated through all the stages of postharvest handling that is harvesting, shelling/ threshing, winnowing, transportation, drying and storages. Storage stage which recorded the second highest postharvest loss at the field survey with a mean of 0.25 (25%), accounted for about 4.9% of total postharvest loss followed by threshing/ shelling/winnowing with 4.25% of total postharvest loss. Deductions can be made from the aforementioned that, there is a high correlation between the field experiment results and the field survey results when it comes to storage. Harvesting, which recorded the highest postharvest loss in the field survey had 2.95% of the total postharvest loss in the field experiment. Drying and transportation recorded 2.05% and 1.4% of total postharvest loss respectively in the field experiment which is not different from the survey results where drying and transportation stages recorded the least postharvest loss with a mean of 0.12 (12%) and 0.02 (2%) respectively. This indicates that there is a strong correlation with the field survey results and the field experiment results when it comes to postharvest

loss estimation of the various stages of postharvest handling activities of maize in the study area. Similarly, Calverley

(1996) observed that postharvest losses for maize ranged from 6 to 10% in some African countries.



## 5.5 CONSTRAINTS ASSOCIATED WITH POSTHARVEST HANDLING OF MAIZE

Several constraints were identified ranging from production to marketing. The degree of severity however varied between the respondents. Lack of storage facilities for their farm products was the severest constrains. It was earlier on mentioned that most of the farmers rely on the traditional storage system which is not very effective and causes a lot of postharvest.

The next constrain was the non-availability of threshing services which is one of the major contributors to postharvest losses around the area. Pilfering and pest infection were also part of constrains associated with postharvest handling of maize. It was however not much of a concern since farmers serve as watchmen for each other's products.

## 6.0 SUMMARY OF FINDINGS, CONCLUSION AND RECOMMENDATIONS

This is the final chapter of the study. It presents a brief recap of the purpose of the study and then summarizes the findings of the study; the necessary conclusions were also drawn and recommendations made to crown the study.



### 6.1 SUMMARY OF FINDINGS

From the results of the study, the following is a summary of the findings of the study;

- The study had 56% of the respondents being males with the mean age of respondents being 38.5 years; 64% of the total number of respondents were married with 33% of them having J.H.S as their highest educational level.

- Most of the respondents were engaged in other income earning activities that is 83% of the total number of respondents while trading happened to be the main other income earning activity as 36% of respondents were engaged in it.

- Intercropping was not practiced by 74% of the total number of respondents while 34% of respondents stored their maize in other places other than ware houses and the traditional storage method. Postharvest losses was being experienced by 91% of the total number of respondents while Aburohoma was the most cultivate variety with 51.8% of respondents cultivating it and the average farm size for maize production was 5.15 acres. The average yield per acre per variety had Aburohoma as the top yielding variety with an average yield of 36.28 bags (120kg bags) depending on the scale of production. The mean total income level for maize was GH¢ 4,215.78 while that of other income earning sources was GH¢ 2,133.68.

- It was at the harvest stage that much of the final product was lost as 0.38 bags (100kg bag) was the highest recorded loss which occurred at the harvest stage.

- Most farmers sold their maize to wholesalers as 74.2% of respondents said they sold their maize to wholesalers.

- The regression analysis to help determine the causes of postharvest losses revealed that; traditional storage and production length were significant at 1% while household size, storage duration and education were significant at 5%.

- Postharvest losses recorded during the field experiment revealed that losses were normally occurring at each stage of postharvest handling with storage accounting for the highest losses and the least occurring during transportation.

- Lack of storage facilities was the greatest constraint associated with the postharvest handling of maize with a mean response of 1.24.

## 6.2 CONCLUSION

The following conclusions can be drawn from the study;

- Respondents were young and had attained some basic education with most of them being males and married.

- Most of the respondents were involved in other income earning activities such as trading from which they earn less from compared to the amount of income they earned from maize production.

- The average acreage of respondents was 5.15 acres with Aburohoma being the most widely cultivated variety and also the highest yielding variety as well.

Intercropping was very less practiced with most respondents using other places of storage other than ware houses and the traditional storage method with majority of the respondents experiencing postharvest losses.

- It was however at the harvesting stage that much of the postharvest losses were recorded in survey whiles the field results indicating that the drying stage recording the highest postharvest losses.

- It was also observed that inadequate storage facilities was the greatest constraint in the postharvest handling of maize and most respondents preferred selling their maize to wholesalers.

- Traditional storage, production length, household size, storage duration and level of education were found to have significant effects on postharvest losses.

## 6.4 RECOMMENDATIONS

From the results of the study and the conclusions drawn the following recommendations were made: since much of the postharvest losses were at the harvest stage, farmers should be re-trained by MOFA on better agronomic practices when it comes to harvesting to help reduce the losses at that stage. Farmers should also be advised to use early maturing varieties as a shorter production length could help reduce postharvest losses; farmers could also be trained on the traditional method of maize storage as it helped reduce postharvest losses while farmers should also do well to reduce the period of storage so as to avoid more losses.

The study finally recommends a comprehensive research on the quality of grains considered to be postharvest loss across the different stages of postharvest handling.

## REFERENCES


**Abass**, A. B., Ndunguru, G., Mamiro, P., Alenkhe, B., Mlingi, N., & Bekunda, M. (2014). Post-harvest food losses in a maize-based farming system of semi-arid savannah area of Tanzania. *Journal of Stored Products Research*. *57*: 49-57.

**Adetunji,** M. O. (2007). Economics of maize storage techniques by farmers in Kwara State, Nigeria. *Pakistan. Journal Social Science*. *4*(3): 442-450.

**Ajirenike**, O. A. (2005). The effect of Ondo State Agricultural Development Project on maize production in Akure North local government area of Ondo State. A project report submitted to the Department of Agricultural Extension and Management Federal College of Agriculture, Akure P61.

**Alderman**, H., (1992). Inter-commodity Price Transmittal. *Oxford Bulletin of Economics and Statistics.* 55(1): 43-64

**Al-Hassan**, R. and Jatoe, J.B. (2002). Adoption and impact of improved cereal varieties in Ghana. In *Workshop on the Green revolution in Asia and its transferability to Africa*. 8th to 10th December, 2002.Tokyo, Japan.

**Atanda,** S.A. Pessu P.O., Agoda, S., Isong I.U. and Ikotun, (2011). The concepts and problems of postharvest food losses in perishable crops. *African Journal of Food Science*. Vol. 5 (11) pp.603-6013, 15 October, 2011.

**Aulakh,** J. and Regmi, A. (2013). Postharvest food losses estimation-Development of consistent methodology. Online available at: http://www.fao.org/ fileadmin /templates/ess/documents/meetings_and_workshops/GS_SAC_2013/Improving_methods_for_estimating_post_harvest_losses/Final_PHLs_Estimation_6-1313.pdf (Accessed on January 19, 2015).

**Boateng**, E. O., Ewusi, K., Kanbur, R. and McKay, A. (1990). A poverty profile for Ghana, 1987–88. Social dimensions of adjustment in Sub-Saharan Africa. *Working Paper No. 5.* Washington, D.C. The World Bank.

**Bell,** A., Mazaud, F. and Mück, O. (1999). Guidelines for the analysis of postproduction systems.

**Boxall,** R. A. (2001). Postharvest losses to insects-a world overview. International Bioterioration and Biodegradtion, 48(1-4), 137-152. Retrieved from www. scopus.com

**Cairns,** J. E., Hellin, J., Sonder, K., Araus, J. L., MacRobert, J. F., Thierfelder, C. and Prasanna, B. M. (2013). Adapting maize production to climate change in subSaharan Africa. *Food Security* 5(3): 345-360.

**Challenges and prospects**. *African Crop Science Conference Proceedings*, Vol. 6. 699-703

**Davad,** B. (2009). Analysis of food consumption patterns of Ghanaians for approximately the past four decades.

**De Groote**, H., Dema, G., Sonda, G. B., & Gitonga, Z. M. (2013). Maize for food and feed in East Africa - The farmers' perspective. *Field Crops Research*. 153:

22-36.

**de Lucia**, M. & Assenato, D. (1994). Agricultural engineering development: Post harvest operations and management of food grains. *FAO Agricultural Service Bulletin*. 93:3. FAO, Rome.

**FAO.** (1983). Food loss prevention in perishable crops.

**FAO.** (1992) Food and agricultural: Maize in human nutrition. FAO Food and Nutrition Series No 25, 82p

**FAO.** (1992). *Maize in Human Nutrition*. FAO Food and Nutrition. FAO Agricultural Services Bulletin. No.43. Food and Agriculture Organization of the United Nations. Rome.

**FAO.** (1996) World agriculture food production Agricultural Organization of the United State. Pp 75

**FAO.** (2004). The Role of Post-harvest Management in Assuring the Quality and Safety of Horticultural Produce. FAO Agricultural Services Bulletin 152. pp 4-7

**FAO.** (2004). The State of the Food Insecurity in the World 2004. FAO, Rome. Assessed from ftp:// ftp.fao.org/docrep/fao/007/y5650e/y5650e00.pdf

**FAO.** (2011). *Global food losses and food waste – Extent, causes and prevention.* Rome

**FAO**. (2011). Global food losses and waste: Extent, Causes and Prevention

**FAO.** (2013). Food wastage footprint: Impacts on natural resources.

**FAOSTAT.** (2014), Africa Maize Production- 2012/13, http:/ /faostat3.fao.org/ browse/ Q/QC/E. Accessed on June 10, 2015.

**Florkowski,** J. and Xi-Ling, W. (1990), Simulating the impact of Pecan Storage Technology on farm price and Grower's income, *Southern Journal of Agricultural Economics Vol.* 22 No.2 pp 217-222.

**Folayan,** J. A. (2013). Determinants of postharvest losses of maize in Akure North Local Government Area of Ondo State, Nigeria, *Journal of Sustainable Society* Vol. 2, No. 1, 12-19

**Grolleaud,** M. (1997). Postharvest losses: Discovering the full story. Rome: FAO. Available from: http://www.fao.org/docrep/004/ ac301e/AC301e04.htm# 3.2.1 %20Rice

**Grolleaud,** M. (2002). Postharvest losses: discovering the full story. Overview of the phenomenon of losses during the postharvest system. Rome, Italy: FAO, Agro Industries and PostHarvest Management Service (AGSI).

**Hodges,** R.J., Buzby, J.C. and Bennett, B (2011), Foresight Project on Global Food and Farming Futures Postharvest Losses and Waste in Developed and Less Developed Countries: Opportunities to Improve Resource Use, *Journal of Agricultural Science V*ol. 149, pp 37–45.

**http:**//faostat.fao.org/site/345/default.aspx

**http:**//www.fao.org/docrep/s8620e/s8620e06.htm

**Kader,** A.A. (2002). Postharvest technology of horticultural crops. 3rd ed. Univ. Calif. Agr.

**Kaiya,** V. (2014) Postharvest losses and strategies to reduce them. *Technical Paper Scientific & Technical Department*, January.

**Kenton L. H. and Lindblad, C. J.** (1976).eds. Postharvest Grain Loss Assessment Methods – A Manual of methods for the Evaluation of Postharvest Losses [5] American Association of Cereals Chemist,

**Kitinoja,** L. and Gorny J.R. (1999). Postharvest technology for small-scale produce marketers: economic opportunities, quality and food safety. Univ. Calif.

*Postharvest Natural Resources,* Oakland, Publ. 3311.

**Lindbland,** C. and Druben, S. (1980). *Small Farm Impact of maize storage on rural household food security in Northern Kwazulu-Natal Grain Storage: Storage methods 3*. New York. Macmillan.

**MoFA-SRID** (2009). Agriculture in Ghana: Facts and Figures 2012. Statistics, Research and Information Directorate. Ministry of Food and Agriculture. Accra, Ghana.

**Morris,** M. L., Tripp, R. B., & Dankyi, A. A. (1999). Adoption and impacts of improved maize production technology: A case study of the Ghana Grains Development Project. Available at http://repository.cimmyt.org:8080/xmlui/handle/10883/975

**Nyambo,** B. T. (1993). Post harvest maize and sorghum grain losses in traditional and improved stores in South Nyanza District, Kenya. *International Journal of Pest Management* 39(2): 181 187.

**Nyoro,** J., Kirimi, L. and Jayne, T. S. (2004). Competitiveness of Kenyan and Ugandan maize production: Challenges for the future. Nairobi: International Development Collaborative Working Papers KE-TEGEMEO-WP-10, Department of Agricultural Economics, Michigan State University.

**Obilana**, O. T. and Fajemisin, J. M. (1977). Methodology for improving maize varieties (*Zea mays) in Nigeria Paper Presented at 3rd National Seed Improvement Course August* 15 – 16 September 1977, Moor Plantation Ibadan, 1-11

**Odendo,** M., H. De Groote and Odongo, O.M. (2001). Assessment of Farmers' Preferences and Constraints to Maize Production In Moist Midaltitude Zone Of Western Kenya. Paper presented at the 5th International Conference of the African Crop Science Society, Lagos, Nigeria October 21-26, 2001

**Odeyemi,** O. O. and Daramola A. M (2000). Storage Practices in the tropics, Volume 1. Food storage and pest problem. First edition (2000). 253p.

**Opio,** F. (2003). Gender mainstreaming in agriculture with special reference to Uganda: Series No. 25. 1–160. Rome: FAO.

**Parfitt,** J., Barthel, M. and Macnaughton, S. (2010). Food waste within food supply chains: quantification and potential for change to 2050

**Raouf,** S.S (2011), Grain yield and physiological growth indices in maize (Zea Mays L.) Hybrids under seed bio priming with plant growth promoting rhizobacteria (PGRR) *Journal of food, Agriculture and Environment* Vol. 9 No. 3&4, pp 393-415.

**Raphael,** I. O. (2008). 'Technical Efficiency of Cassava Farmers in South Eastern Nigeria: Stochastic Frontier Approach'. *Medwell Online Agricultural Journal* 3(3): 152-156.

**Shepherd, A. W.** (2012). Grain Storage in Africa: Learning from past experiences. Food Chain 2 (2) 149 – 163.

**Suleiman,** R. and Rosentrater, K. (2015). Current Maize Production, Postharvest Losses and the Risk of Mycotoxins Contamination in Tanzania Written for Presentation at the 2015 ASABE Annual International Meeting *Paper Number: 152189434* New Orleans, Louisiana July 26 – 29, 2015

**Suleiman,** R. A., Rosentrater, K. A., & Bern, C. J. (2013). Effects of deterioration parameters on storage of maize: A review. *Journal of Natural Sciences Research. 3*(9): 147.

**Tefera,** T. (2012). Postharvest losses in African maize in the face of increasing food shortage, *Food Security* 4(2): 267-277.

**Thamaga-Chitja,** J. M., Hendriks, S. L., Ortmann, G. F. and Green, M. (2004) Impact of maize storage on rural household food security in Northern Kwazulu-Natal, *Journal of Family Ecology and Consumer Sciences*, Vol. 32, pp 8-15

**Tilman**, D., Cassman, K.G., Matson, P.A, Naylor, R. and Polasky, S. (2002). Agricultural sustainability and intensive production practices Nature Publishing Group, USA

**Tyler,** P. S and Gilman, G. A. (1979). L'évaluation des pertes post re'çolt. Séminaire de Bamako. pp 137-141.

**Umeh,** G. N. and Odom, C. N., (2011). *Roles and Constraints of youths' associations in agricultural and rural development*, IDOS Publications: Nigeria.

**Verheye,** W. (2010). Growth and Production of Maize: Traditional Low-Input Cultivation. In: Land Use, Land Cover and Soil Sciences. Encyclopedia of

Life Support Systems (EOLSS), UNESCO-EOLSS Publishers, Oxford, UK. Online available at: http://www.eolss.net. Accessed on April 16, 2016.

**Woomer,** P.L., Langat, M and Tungani, J.O. (2004) Innovative Maize-legume Intercropping Results in Above- and Below-ground Competitive Advantage for Understorey Legumes, West African Journal of Ecology, Vol. 6 pp 85-94.

**World Bank**, FAO and NRI, (2011), Missing Food: the Case of Postharvest Grain Losses in Sub-Saharan Africa. In: Economic Sector Work Report No. 60371-AFR. World Bank, Washington, DC.

**Zorya,** S., Morgan, N. and Rios, L.D. (2011). *Missing food: The Case of Postharvest Grain Losses in Sub-Saharan Africa*. The International Bank for Reconstruc - tion and Development/ The World Bank. Report No. 60371-AFR. The World Bank, Washington, DC.

## APPENDIX ONE: RESEARCH QUESTIONNAIRE

**Kwame Nkrumah University of Science and Technology**

Faculty of Agriculture**;** Department of Horticulture**,**

*Determining the Factors Influencing Postharvest Loses of Maize in the Ejura – Sekyedumase Municipality of the Ashanti Region of Ghana.*



**Part I: Identification & Demographics**

1. Questionnaire No ….. Community ID …… Name of Respondent ……
2. Age of respondent: ……
3. Gender of respondent 1. Male [ ] 2. Female [ ]
4. Marital status: 1. Single [ ] 2. Married [ ]
5. Educational background: a. Primary [ ] b. J.S.S./Middle School [ ] c. S.H.S/O/A Level [ ] d. tertiary [ ] e. Others (please specify ……..)
6. Number of years spent in formal school……
7. Farm size …….
8. Do you undertake intercropping Yes/No
9. Variety of maize planted 1.

| Maize variety | Tick as applicable | Proportion of field planted | Farm size planted with the variety | Yield |
|---|---|---|---|---|
| Obaatanpa | | | | |
| Okomasa | | | | |
| Aburontia | | | | |
| Panaa | | | | |
| Dobidi | | | | |
| Aburohoma | | | | |

Other, specify ……..

10. Household size ……

11. How much is your income from maize sales in last year 2014 (both minor and major season) ……

12. Do you engage in any other income earning activities? Yes / No

13. If yes which income earning activities do you engage in? a. Trading [ ] b. Farming [ ] c. Teaching [ ] d. Others (specify ……)

14. About how much do you earn in a month? A. less than GH¢50 b. GH¢51-100 c.GH¢ 101-150, d. above GH¢150

15. About how much do you earn from other income sources in a year. GH¢ …

16. For how long have you been producing maize ……

**Part II: Farm Characteristics & Postharvest Loses (tell me about the most recent season)**

17. How much maize did you produce? ……

18. Complete the following table:

| | Total harvest | Amt sold immediately after harvest | Amt stored | Duration of storage | Amt consumed | Amt given as gifts and in kind payments | Amt reserved for planting |
|---|---|---|---|---|---|---|---|
| Qty (Kg) | | | | | | | |

19. Do you experience postharvest lost? 1. Yes [ ] 0. No [ ]

20. What was the level of postharvest lost per acre during the following activities?

| Activity | Harvesting | Transportation | Threshing | Winnowing | Drying | Storage | Total loss |
|---|---|---|---|---|---|---|---|
| Quantity lost (kg) | | | | | | | |

21. Indicate quantity and proportion of postharvest lost per acre that can be attributed to the following:

| Type of lose | Rodents spoilage | Weevils spoilage | Discoloration | Broken |
|---|---|---|---|---|

| | | | | |
|---|---|---|---|---|
| Quantity (kg) | | | | |
| Proportion in % | | | | |

22. Whom did you sell your produce to?

| Type of buyers | Tick as applicable | Indicate proportion or percentage sold to each |
|---|---|---|
| Consumers | | |
| Retailers | | |
| Wholesalers | | |
| Producers | | |
| Farmer organization | | |
| Company ( NGOs, Govt, etc) | | |
| Other, specify | | |

**Part III: Constraints being faced in Postharvest Handling in Maize.**

Please tick where appropriate.

23. Which of these constraints do you face in postharvest handling of maize?

| To what extent do you agree to these constraints? | Strongly agree/very severe | Agree severe | Neutral/ moderate | Disagree/ less severe | Strongly disagree/ not severe |
|---|---|---|---|---|---|
| Lack (or inadequate ) storage facilities | | | | | |
| Non – availability of threshing services on time | | | | | |
| High transport cost | | | | | |
| Pests | | | | | |
| Pilfering | | | | | |
| Difficulty finding buyers | | | | | |
| Unstable pricing | | | | | |
| Harvesting during peak raining season | | | | | |
| Other | | | | | |

24. Where do you store you maize? 1. Traditional storage [ ] 2. Warehouse [ ] 3.

Other, specify …….

Why to question 25? Or why that storage choice.

## APPENDIX TWO: RESULTS FROM FIELD EXPERIMENT

## POSTHARVEST LOSS AT EACH STAGE OF HANDLING

### HARVESTING (PER ACRE) - (1)

**MAJOR SEASON** **MINOR SEASON**

| FARM ID | TOTAL QUANTITY AFTER HARVEST | TOTAL QUANTITY AFTER REHARVESTING | Percentage loss | | FARM ID | TOTAL QUANTITY AFTER HARVESTING | TOTAL QUANTITY AFTER REHARVESTING | Percentage loss |
|---|---|---|---|---|---|---|---|---|
| | Kg | Kg | | | | kg | kg | |
| | A | B(Postharvest Loss) | | | | A | B (Postharvest Loss) | |
| **A** | 700 | 21.6 | 3.0 | | A | 850 | 16.45 | 1.9 |
| **B** | 900 | 14.4 | 1.6 | | B | 760 | 31.5 | 4.1 |
| **C** | 950 | 18.9 | 2.0 | | C | 1450 | 44 | 3 |
| **D** | 650 | 9 | 1.4 | | D | 1000 | 13..50 | 1.4 |
| **E** | 1100 | 14.4 | 1.3 | | E | 1140 | 24.3 | 2.1 |
| **F** | 970 | 30.3 | 3.1 | | F | 900 | 60 | 6.7 |
| **G** | 1440 | 17.7 | 1.2 | | G | 1050 | 12 | 1.1 |
| **H** | 1350 | 40.9 | 3.0 | | H | 450 | 31.5 | 7.0 |
| **I** | 830 | 34.13 | 4.1 | | I | 700 | 13.5 | 2.0 |
| **J** | 1050 | 11.41 | 1.1 | | J | 950 | 75 | 7.9 |
| **MEAN** | **994** | **21.274** | **2.2** | | | **925** | **30.825** | **3.7** |

### THRESHING/ SHELLING AND WINNOWING (PER ACRE)-(2)

**MAJOR SEASON**

| Farm ID | Total Quantity Realized After Shelling Winnowing (Kg) | Total Quantity Realized after Re-threshing Shelling and Winnowing (Postharvest loss) Kg | Percentage loss |
|---|---|---|---|
| **A** | 1100 | 60 | 5.5 |
| **B** | 500 | 19 | 3.8 |
| **C** | 1050 | 49 | 4.7 |
| **D** | 950 | 22 | 2.3 |
| **E** | 1400 | 80 | 5.7 |
| **F** | 650 | 36.5 | 5.6 |
| **G** | 800 | 16 | 2 |
| **H** | 1200 | 41.5 | 3.5 |
| **I** | 1000 | 40 | 4 |
| **J** | 700 | 55 | 7.9 |
| **MEAN** | **935** | **41.9** | **4.5** |

**MINOR SEASON**

| Farm ID | Total quantity realized after Threshing, Shelling and Winnowing (100 Kg) | Total Quantity Realized after Re-threshing, shelling and winnowing (postharvest loss) in kg | Percentage loss |
|---|---|---|---|
| A | 1250 | 25.5 | 2 |
| B | 950 | 24 | 2.5 |
| C | 1200 | 43.5 | 3.6 |
| D | 850 | 65 | 7.6 |
| E | 1300 | 35.5 | 2.7 |
| F | 1700 | 70 | 4.1 |
| G | 1200 | 16 | 1.3 |
| H | 800 | 50 | 6.2 |
| I | 700 | 49 | 7 |
| J | 750 | 19.5 | 2.6 |
| **MEAN** | **107** | **39.8** | **4.0** |

**DRYING (SUN) 3**

**MAJOR SEASON** **MINOR SEASON**

| | Duration Of drying (days) | | | | Duration OF Drying (days) | | |
|---|---|---|---|---|---|---|---|
| | 2 Day | 4 Days | 6 Days | | 2 Day | 4 Days | 6 Days |
| NO. OF BAGS BEFORE DRYING (100kg) =10 | 9.89 | 9.80 | 9.71 | NO. OF BAGS BEFORE DRYING (100kg) =10 | 9.96 | 9.93 | 9.84 |
| TOTAL WEIGHT BEFORE DRYING (KG) 1000 | 989 | 980 | 975 | TOTAL WEIGHT BEFORE DRYING (KG) 1000 | 996 | 993 | 984 |
| MOISTURE CONTENT BEFORE DRYING 23 (%) | 21.5 | 19.7 | 18.3 | MOISTURE CONTENT BEFORE DRYING 18 (%) | 16.2 | 15.0 | 14.4 |
| **TOTAL LOSS = 25KG** | | | | **TOTAL LOSS = 16KG** | | | |
| **Percentage loss = 2.5** | | | | **Percentage loss = 1.6** | | | |

**STORAGE-TRADITIONAL (4)**

## MAJOR SEASON

| | WEIGHT BEFORE STORAGE (kg) | WEIGHT AFTER STORAGE IN (kg) | | | | | | Total weight Loss (kg) | Percentage Loss |
|---|---|---|---|---|---|---|---|---|---|
| BAG ID | | 2 Weeks | 4 Weeks | 6 Weeks | 8 Weeks | 10 Weeks | 12 Weeks | | |
| | $T^O$ =27.3 R.H =70 M.C(%) =23.0 | $T^O$ =27.6 R.H =76 M.C =20.60 | $T^O$ =27.8 R.H =76 M.C =20.09 | $T^O$ =29.7 R.H =72 M.C =19.04 | $T^O$ =27.1 R.H =85 M.C =18.99 | $T^O$ =29.8 R.H =69 M.C =17.09 | $T^O$ =30.1 R.H =73 M.C =16.13 | | |
| A | 124 | 124 | 124 | 123 | 123 | 122 | 120 | 4 | 3.2 |
| B | 119 | 116 | 116 | 115 | 115 | 112 | 112 | 7 | 5.9 |
| C | 123 | 123 | 123 | 123 | 123 | 121 | 120 | 3 | 2.4 |
| D | 123 | 123 | 123 | 123 | 122 | 119 | 117 | 6 | 4.9 |
| E | 128 | 130 | 129 | 130 | 129 | 126 | 125 | 3 | 2.3 |
| F | 118 | 118 | 118 | 118 | 117 | 114 | 111 | 7 | 5.9 |
| G | 134 | 134 | 134 | 133 | 133 | 131 | 128 | 6 | 4.4 |
| H | 126 | 126 | 125 | 125 | 124 | 122 | 118 | 8 | 6.3 |
| I | 120 | 120 | 120 | 120 | 118 | 115 | 113 | 7 | 5.8 |
| J | 125 | 124 | 124 | 124 | 122 | 119 | 116 | 9 | 7.2 |
| K | 126 | 126 | 126 | 126 | 120 | 118 | 114 | 12 | 9.5 |
| L | 125 | 125 | 125 | 124 | 124 | 121 | 118 | 7 | 5.6 |
| M | 130 | 130 | 130 | 130 | 128 | 126 | 126 | 4 | 3.1 |
| N | 127 | 126 | 126 | 126 | 125 | 124 | 122 | 5 | 3.9 |
| O | 120 | 119 | 120 | 120 | 119 | 117 | 116 | 4 | 3.3 |
| P | 122 | 120 | 120 | 119 | 117 | 112 | 109 | 13 | 10.7 |
| Q | 134 | 134 | 133 | 133 | 132 | 130 | 127 | 7 | 5.2 |
| R | 134 | 134 | 134 | 134 | 130 | 127 | 126 | 8 | 5.9 |
| S | 136 | 135 | 135 | 134 | 132 | 131 | 131 | 5 | 3.7 |
| T | 124 | 124 | 124 | 123 | 120 | 118 | 116 | 8 | 6.5 |
| **MEAN** | **125.90** | **125.55** | **125.45** | **125.15** | **123.65** | **121.25** | **119.25** | 6.65 | 5.3 |

## MINOR SEASON

| | Weight Before Storage (kg) | WEIGHT AFTER STORAGE IN (kg) | | | | | | Total weight Loss (kg) | Percentage Lo |
|---|---|---|---|---|---|---|---|---|---|
| BAG ID | | 2 Weeks | 4 Weeks | 6 Weeks | 8 Weeks | 10 Weeks | 12 Weeks | | |
| | $T^O$ =31.5 R.H =64 M.C(%) =18.01 | $T^O$ =30.3 R.H =63 M.C =17.44 | $T^O$ =28.3 R.H =30 M.C =16.06 | $T^O$ =27.4 R.H =23 M.C =16.01 | $T^O$ =31.3 R.H =60 M.C =15.40 | $T^O$ =31.5 R.H =64 M.C =14.88 | $T^O$ =30.9 R.H =62 M.C =13.08 | | |
| A | 130 | 130 | 130 | 130 | 128 | 126 | 123 | 7 | 5.4 |
| B | 127 | 127 | 127 | 127 | 126 | 123 | 121 | 6 | 4.7 |
| C | 126 | 126 | 126 | 126 | 126 | 124 | 123 | 3 | 2.4 |
| D | 127 | 127 | 127 | 126 | 126 | 124 | 121 | 6 | 4.7 |
| E | 127 | 127 | 127 | 126 | 120 | 117 | 113 | 14 | 11.0 |
| F | 123 | 123 | 123 | 123 | 120 | 119 | 117 | 6 | 4.9 |
| G | 134 | 134 | 134 | 133 | 133 | 132 | 130 | 4 | 3.0 |
| H | 121 | 121 | 120 | 120 | 121 | 120 | 117 | 4 | 3.3 |
| I | 134 | 134 | 134 | 134 | 133 | 130 | 130 | 4 | 3.0 |
| J | 131 | 130 | 130 | 128 | 128 | 124 | 122 | 9 | 6.9 |
| K | 118 | 118 | 118 | 117 | 117 | 115 | 113 | 5 | 4.2 |
| L | 119 | 119 | 118 | 117 | 117 | 116 | 116 | 3 | 2.5 |
| M | 130 | 131 | 130 | 130 | 129 | 126 | 124 | 6 | 4.6 |
| N | 131 | 131 | 131 | 131 | 130 | 127 | 126 | 5 | 3.8 |
| O | 125 | 125 | 125 | 125 | 124 | 122 | 120 | 5 | 4.0 |
| P | 126 | 126 | 126 | 126 | 125 | 121 | 120 | 6 | 4.8 |
| Q | 128 | 128 | 127 | 127 | 127 | 125 | 122 | 6 | 4.7 |
| R | 124 | 123 | 123 | 122 | 122 | 122 | 120 | 4 | 3.2 |
| S | 130 | 129 | 129 | 128 | 128 | 126 | 124 | 6 | 4.6 |
| T | 129 | 129 | 129 | 127 | 127 | 125 | 123 | 6 | 4.7 |
| **MEAN** | **127.00** | **126.90** | **126.70** | **126.15** | **125.35** | **123.20** | **121.25** | **5.75** | **4.5** |

## TRANSPORTATION (5)

**MAJOR SEASON**

| BAG ID | WEIGHT BEFORE TRANSPORT kg | WEIGHT AFTER TRANSPORT kg | TOTAL WEIGHT LOSS Kg | Percentage loss |
|---|---|---|---|---|
| 1 | 122 | 122 | 0 | **0.0** |
| **2** | 131 | 130 | 1 | **0.8** |
| **3** | 105 | 105 | 0 | **0.0** |
| **4** | 117 | 116 | 1 | **0.9** |
| **5** | 134 | 130 | 4 | **3.0** |
| **6** | 126 | 109 | 17 | **13.5** |
| **7** | 119 | 114 | 5 | **4.2** |
| **8** | 136 | 133 | 3 | **2.2** |
| **9** | 128 | 128 | 0 | **0.0** |
| **10** | 124 | 124 | 0 | **0.0** |
| **11** | 121 | 120 | 1 | **0.8** |
| **12** | 122 | 122 | 0 | **0.0** |
| **13** | 130 | 130 | 0 | **0.0** |
| **14** | 127 | 124 | 3 | **2.4** |
| **15** | 109 | 109 | 0 | **0.0** |
| **16** | 124 | 123 | 1 | **0.8** |
| **17** | 130 | 127 | 3 | **2.3** |
| **18** | 128 | 128 | 0 | **0.0** |
| **19** | 128 | 128 | 0 | **0.0** |

**MINOR SEASON**

| BAG ID | WEIGHT BEFORE TRANSPORT Kg | WEIGHT AFTER TRANSPORT kg | TOTAL WEIGHT LOSS kg | Percentage loss |
|---|---|---|---|---|
| 1 | 121 | 120 | 1 | 0.8 |
| 2 | 124 | 123 | 1 | 0.8 |
| 3 | 130 | 130 | 0 | 0.0 |
| 4 | 120 | 118 | 2 | 1.7 |
| 5 | 133 | 130 | 3 | 2.3 |
| 6 | 127 | 127 | 0 | 0.0 |
| 7 | 127 | 127 | 0 | 0.0 |
| 8 | 124 | 121 | 3 | 2.4 |
| 9 | 120 | 120 | 0 | 0.0 |
| 10 | 135 | 133 | 2 | 1.5 |
| 11 | 129 | 128 | 1 | 0.8 |
| 12 | 121 | 121 | 0 | 0.0 |
| 13 | 119 | 117 | 2 | 1.7 |
| 14 | 122 | 122 | 0 | 0.0 |
| 15 | 136 | 136 | 0 | 0.0 |
| 16 | 109 | 108 | 1 | 0.9 |
| 17 | 125 | 124 | 1 | 0.8 |
| 18 | 130 | 128 | 2 | 1.5 |
| 19 | 131 | 126 | 5 | 3.8 |

| | | | | |
|---|---|---|---|---|
| **20** | 127 | 126 | 1 | **0.8** |
| **MEAN** | **123.55** | **122.45** | **1.2** | **1.7** |

| | | | | |
|---|---|---|---|---|
| 20 | 124 | 121 | 3 | 2.4 |
| **MEAN** | **125.35** | **124.15** | **1.3** | **1.1** |