Research Paper

Future of Food: Journal on Food, Agriculture and Society
10 (3) July 2022

Adoption and effectiveness of hermetic storage bags to reduce staple food postharvest loss for sustainability in the Ejura-Sekyedumase Municipality, Ghana

SHINE FRANCIS GBEDEMAH[1*], ANN AFUA HARRISON-AFFUL[2] AND LOUIS KUSI FRIMPONG[1]

[1]Department of Geography & Earth Sciences, University of Environment and Sustainable Development, PMB, Somanya, Ghana.
[2] Department of Agriculture, Greater Accra Regional Coordinating Council, Engineering Unit, Accra, Ghana.

* Corresponding author: sfkgbedemah@gmail.com

Data of the article

First received : 04 November 2021 | Last revision received : 19 April 2022
Accepted : 22 June 2022 | Published online : 31July 2022
DOI : 10.17170/kobra-202204136012

Keywords

postharvest loss; hermetic bags; adoption; effectiveness; Ejura-Sekyedumase

Postharvest loss is a major problem facing agricultural households in the global south. It is in this context that the introduction of hermetic storage bags is viewed by many as a key solution to averting postharvest loss, especially for grains which are essential to food security. While there have been policy efforts to increase the availability of hermetic storage bags for farmers, little is known regarding the extent of its adoption and effectiveness in reducing grain loss. This study fills this empirical vacuum by examining the extent of the adoption of hermetic storage bags and their effectiveness in reducing grain loss. The study uses a mixed-methods approach, combining data from a cross-sectional survey, in-depth interviews, and field observations. The result shows that the majority of respondents have moved away from chemical and traditional grain storage methods and are using hermetic storage bags. The result also shows that the hermetic storage bags were effective in improving seed viability, reducing moisture level, reducing grain loss, and reducing grain damage. The authors recommend periodic training and sensitization activities for farmers to improve awareness and ultimately adoption of hermetic storage bags by all farmers.

1. Introduction

A staple food can be said to be a food that is mainly eaten in such quantities that it becomes a dominant portion of that person, family, community, town, or country's standard diet. Staple foods in the tropics are mainly grains or cereals. Food grains are the most commonly stored food commodities in the tropics and sub-tropics. The grains are usually stored as food for humans and livestock while seeds are stored for planting for the ensuing cultivation period. The major grains cultivated in the tropics and subtropical countries are maize, rice, wheat, sorghum, cowpea, soybean, pigeon pea, kidney bean, black gram, and lentil (Asif et al., 2013). Stored food grains are essential for most households in countries in tropical and sub-tropical regions. They sustain the livelihoods of agricultural households by reducing postharvest loss and guaranteeing food security for most countries (Grote et al., 2021).

Globally, "around 14 percent of food produced is lost from the post-harvest stage up, but excluding, the retail stage" (FAO, 2019; 22). Postharvest losses are thus, a major cause of concern worldwide, yet only about 5% of research funding has been allocated to addressing this problem (Rajashekar et al., 2012). Postharvest loss comprises crop loss across the agriculture value chain from harvesting of crops until their consumption (Aulakh et al., 2013). According to Aulakh et al.

(2013), food loss is defined as food that is available for human consumption but is not consumed. The losses can generally be characterized as weight loss due to spoilage, quality loss, nutritional loss, seed viability loss, and commercial loss (Boxal, 2001). The magnitude of postharvest losses in the food supply chain varies among different crops and geographical regions. Averting postharvest losses has therefore become a priority and requires investment into methods and technologies that will ensure high returns rather than just increasing crop production to meet food demands. Doing this is important because postharvest losses caused by insect and pest infestation are a major problem for farmers, who lose about 20%-50% of food grains annually across Africa (Aboagye et al., 2017). The food security problem in West Africa is largely due to the inability to preserve food surpluses during the main harvest period. This affects the economy of developing countries because agricultural production is seasonal (Rajashekar et al., 2014).

Agriculture is the backbone of the economy of most Sub-Saharan African countries and contributes significantly to the GDP of the country. Grains play a major role in the food production and diet of people in Ghana. Almost all the households in Ghana eat one or more grains in their daily meal, which makes grain production and storage important to ensure that the country is food secure (Aboagye et al., 2017). Figure 1 below shows the total estimated production values of maize and cowpea in Ghana between 2008 and 2020 in metric tons. The figure shows increased production between 2019 and 2020, indicating that grain production is contributing substantially to the country's economy.

Unfortunately, inadequate postharvest facilities and inappropriate storage methods have hampered Ghana's efforts in sustaining grain yields. This situation has resulted in a considerable loss of agricultural produce and reduced earnings for most farming households. The usual practice for farmers is to store grains temporarily for a month or two before transferring them to a storage structure after harvest (Adejumo, 2007). Those without storage facilities have to sell the grains straight away in the market. Farmers who store the grains before selling experience postharvest loss. For instance, farmers in Ghana lose about 5% - 20% of their cereals through postharvest loss (Sugri et al., 2021) and this affects the country's food security situation.

In 2008, the Ministry of Food and Agriculture introduced hermetic storage bags (Super Grain bags, GrainPro-Cocoon) to grain farmers across Ghana. Farmers use these hermetic storage bags to store their seedlings to control insect infestation and preserve the quality of the grain without using chemicals. Farmers also use hermetic bags to store their commodities for

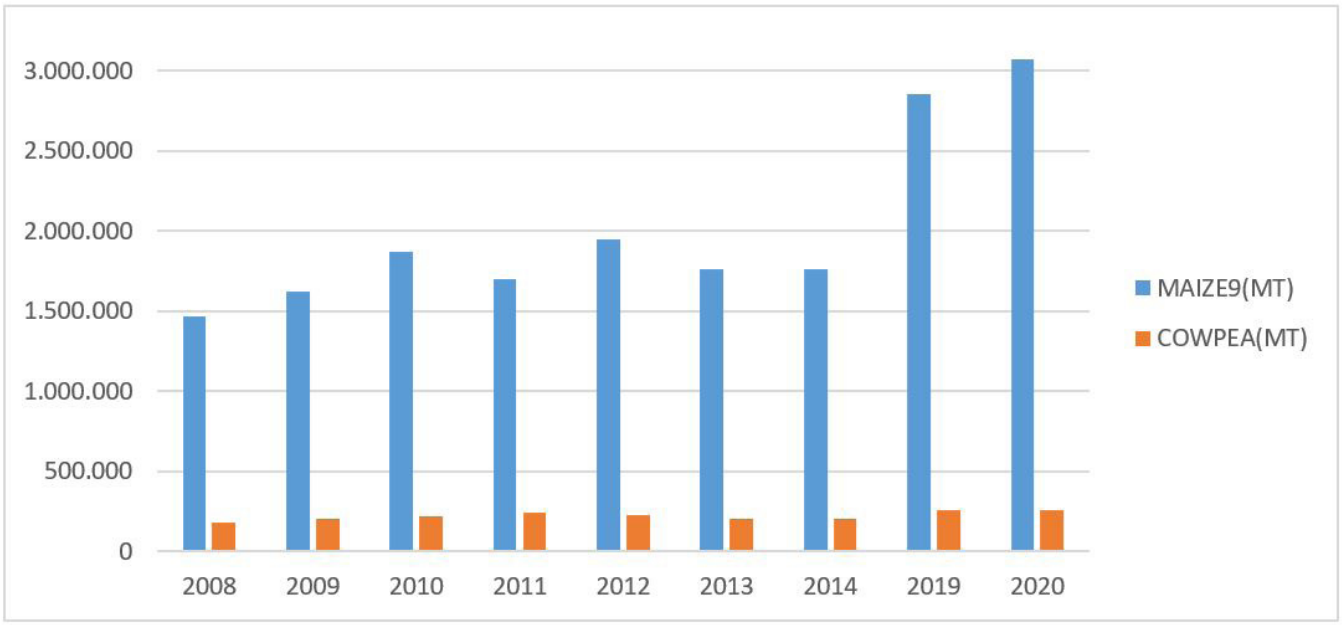

Figure 1. Estimated Production values for Maize and Cowpea (2008-2020) Source: MOFA SRID, 2020

ISSN-Internet 2197-411x OLCL 862804632

the long period and sell them during the lean season (FAO, 2017). Undoubtedly, hermetic storage bags could be key to reducing postharvest loss of grains in Ghana, and it is for this reason that knowledge about its acceptability and adoption by farmers is critical to policy efforts aimed at improving the use of this storage method to enhance food security in Ghana. There are few studies on farmers' adoption and the effects of hermetic storage bags in Ghana. For instance, Fusseini (2015) indicates that farmers in the Techiman Municipality who adopted the hermetic bag technology have improved food security in their households and obtained higher prices for their produce during the lean season. While this is insightful, there is a need for further studies on the adoption of hermetic storage bags in other agriculturally-based regions or communities in Ghana to provide much breadth and understanding of the impact and effectiveness of this storage technology, especially from the perspective of farmers. Aside from this, there is also the need to understand how the adoption of hermetic storage has affected traditional or other previously known methods of grain storage. This study seeks to contribute to research on farmers' adoption of hermetic storage bags in Ghana. The objective of this study is to examine the extent of adoption of hermetic storage bags among farming households and the effectiveness of their use. The study is conducted in the Ejura-Sekyedumase Municipality, which is an important farming region in Ghana and also regarded as the 'cone basket' of the Ashanti region.

2. Study Area and Methods

2.1 Study area

Ejura-Sekyedumase is located in the northern part of the Ashanti region. It shares a boundary with Atebubu Amantin District and Nkoranza North in the north and Nkoranza South in the north-eastern section of the municipality. Ejura-Sekyedumase Municipality also shares a boundary with Mampong Municipality, Sekyere South District, and Offinso Municipality to the east, south, and west respectively (refer to Fig 2). The location of Ejura-Sekyedumase gives it a unique identity as a geographical area that traverses the semi-deciduous and middle-belt vegetation zones. The rainfall pattern of the Municipality is characterised by the bi-modal rainfall pattern (GSS, 2014). This rainfall pattern is unique to the forest and deciduous regions of Ghana while the uni-modal rainfall pattern is also unique to the middle-belt and savannah regions of the country. The vegetation and climatic features of the Municipality have also influenced the soil type in the area which is predominantly Savannah ochrosol soils (Adjei-Gyapong & Asiamah, 2002). This type of soil is suitable for agriculture, and it is noted to support the bulk of the country's food crops.

According to GSS (2014), the population of the Municipality is about 85,456. The proportion of the working-age population (15 to 64 years) is about 55%, with 41% of the population below the age of 15 years (GSS, 2014). Agriculture is the main source of employment in the Municipality, employing about 70% of the population. Crop production constitutes the major agricultural activity. A sizeable proportion of the population is migrants (34%) who have migrated to the Municipality to engage in agriculture. It was reported that 32% of the migrant population has lived in the area for not more than 5 years (GSS, 2014).
Some of the main reasons for choosing this study area were based on the objective of the study, and in particular, access to the study population who engage in cereal farming where the incidence of postharvest losses was reported to be of concern to farmers and marketers. It should also be noted that this district was selected for the study because it was one of the districts in Ghana which was targeted by the government to disseminate the use of the hermetic storage device.

2.2. Research design

The study adopted a mixed-methods research approach. The mixed-methods research approach involves the use of qualitative and quantitative approaches and seeks to reduce the limitations that would have been present in a study if either qualitative or quantitative research approach was used for such a study (Creswell & Plano Clark, 2007). According to Onwuegbuzie & Leech (2005) using mixed methodologies in the same study provides an opportunity to delve deeper into a study and allows for cross-validation of different datasets. By this, knowledge generated often reflects the complexity of the problem under investigation. It is in this light that Creswell (2009) argues that the adoption of mixed methods by social science researchers reflects the need to understand the complexity of social reality. More so, Creswell (2014)

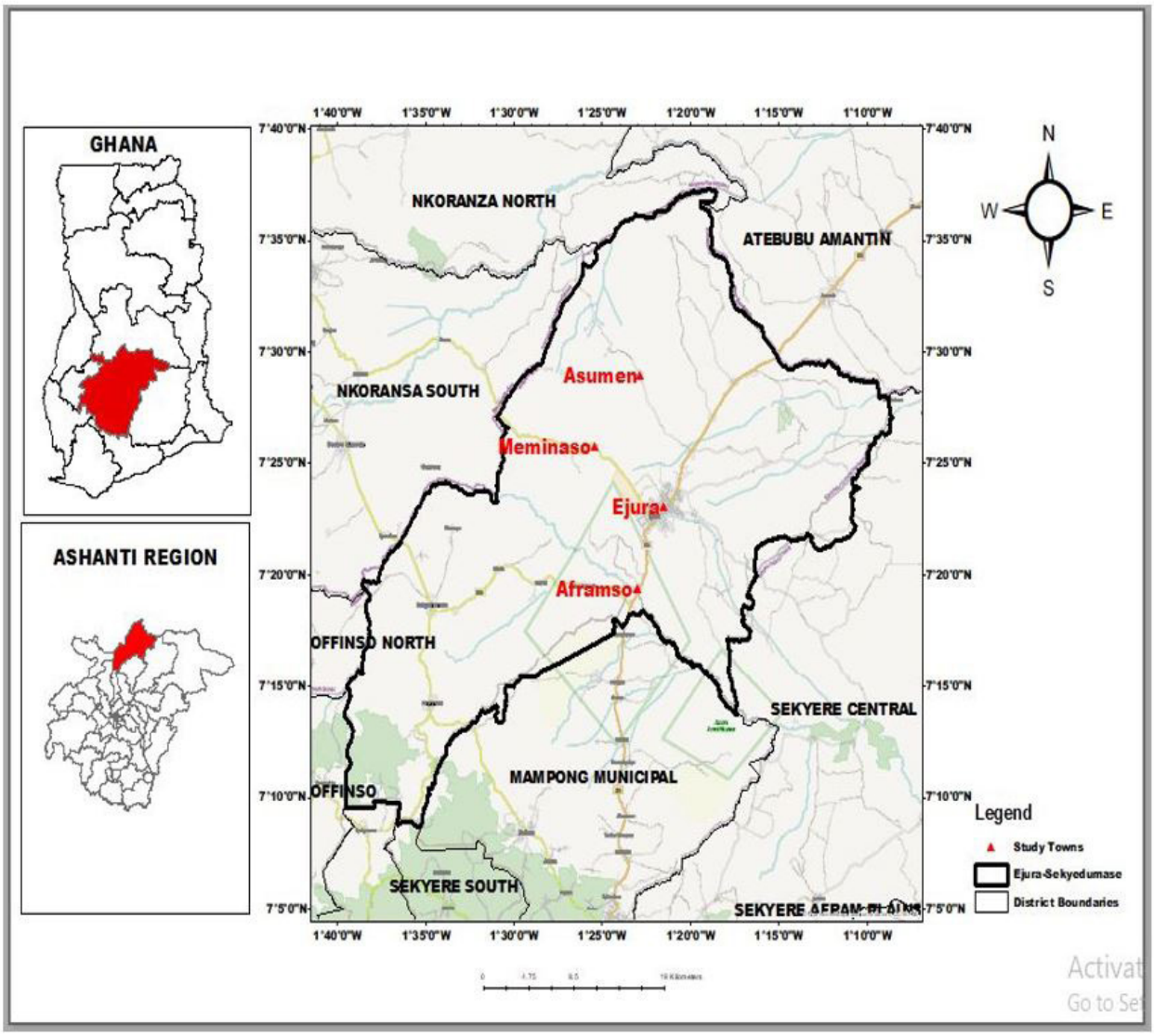

Figure 2. Location of Ejura-Sekyedumase Municipal in Ghana. Source: Ejura-Sekyedumase District Assembly, 2016

argues that the choice of research approaches, including the mixed-methods approach, is based largely on the research objectives and goal.

Aside from the research approach which provides the broad research direction and orientation, the convergence parallel mixed-methods design was used. With this design, both quantitative and qualitative data sources used for the study were collected at the same time and merged in the data analysis (Creswell & Plano Clark, 2007) to provide a comprehensive understanding of the adoption of hermetic storage technology and the effectiveness in their usage from the perspective of farmers. The design strategy enabled the researchers to comprehend the data well as they have been collected at the same time. It also allowed the researchers to quickly notice areas in the data where there were convergence or contradictions.

2.3 Target population and sample size determination

The population for the study was farmers who are into crop production in both rural and urban areas of the Municipality. The reason for sampling both rural and urban communities was that 86% of the rural population are engaged in food crop production and most farmers are into the cultivation of more than one food crop including cereal crops. Also, most farmers sell the crop to marketers in urban areas. Thus, there was a high probability that close to 90% of farmers in the communities who would participate in the sur-

ISSN-Internet 2197-411x OLCL 862804632
UniKassel & VDW, Germany- July 2022

vey, were also more likely to be involved in cereal crop production and marketing. Respondents were heads of farming households.

Regarding the sample size, a total sample of 180 respondents was sampled from three rural communities in addition to Ejura. The researchers arrived at the sample using a confidence level of 95%, an associated margin of error of 7%, and an estimated household number of 3000. This was the estimated household number given to the researchers by the municipal statistical officer. The sample was calculated using the formula below:

$$n = \frac{N}{1 + N(e)^2}$$

Where n is the sample size, N is the population size, and e is the level of precision.

2.4. Sampling technique

In the absence of a household list that would have been used as a sample frame from which the survey data would have been collected, the researchers used the dwelling units in the three rural communities and Ejura suburbs as the sample frame. The number of houses in the communities were generated through a count of the housing units in the study communities using the Google Earth application. The researchers arrived at an estimated housing unit of 400, approximately 130, 115, and 105 were used for Saboline in Ejura, Asumen, and Aframso communities respectively. All houses were listed, and 60 houses were randomly sampled from each community in the generated list of houses. One household head was then sampled from the houses and a final sample figure of 180 was arrived at for the communities.

2.5. Selection of qualitative interview participants

In terms of the qualitative data, a focus group was organized for the farmers in Saboline (Ejura) and Meminaso to gather data from the respondents. The participants in the FGD were mainly large, medium and small scale farmers cultivating maize. Only people seen as knowledgeable to provide information concerning the adoption of the new technology were selected. For the focus group, six (6) large-scale farmers, four (4) medium-scale farmers, and two (2) small-scale farmers were used. Additionally, four (4) agricultural extension experts in the Ejura-Sekyedumase Municipality of the Ministry of Agriculture were also interviewed. Information on reasons for adoption, usage pattern, and perceived effectiveness compared to the traditional methods in reducing postharvest loss in grain storage were solicited from them.

2.6. Data analysis

Data collected through the survey were coded, cleaned, and prepared for analysis using the Statistical Package for Social Sciences (SPSS). Both descriptive statistics in the form of tables and frequencies were used to describe the extent of adoption, and effectiveness of hermetic storage technology. Similarly, interviews were recorded using a tape recorder and transcribed into English. The transcribed interviews were coded and processed with N-Vivo software. Themes linked to the study objectives were generated from the transcripts and quotations emanating from the themes were presented together with the survey results. The quotations provided further insight and also corroborate the survey result.

3. Results

3.1. Background of respondents

Table 1 shows the demographic background of respondents using variables such as gender, age, educational level, and marital status. The result shows that majority of the respondents were males (68%), compared to females (32%). The reported results for gender are not surprising given the predominance of male-headed households in the study area (see GSS, 2014), and to a large extent the male-dominated agricultural households in the country (GSS, 2020). The majority of respondents were between the ages of 26-35 years (50%) and 36-45 (20%). The results show that household heads were within their youthful age, which can be beneficial to agricultural output since this also shows an active labour force. The age distribution also reflects largely the age structure of the district and the country as a whole. Further, the majority of farmers surveyed were married (77%).
Regarding the level of education, the result shows

Table 1. Demographic characteristics of respondents

Variable	Categories	#	%
Gender	Male	123	68.3
	Female	57	31.7
Age	18-25	15	8.3
	26-35	90	50.0
	36-45	36	20.0
	46-55	21	11.7
	Above 56 yrs.	18	10.0
Educational	No Formal education	78	43.3
	Basic school	45	25.0
	Secondary/A-level	27	15.0
	Diploma/Degree	30	16.7
Marital status	Single	27	15.0
	Married	138	76.7
	Divorced	9	5.0
	Widowed	6	3.3

that majority of respondents had no formal education (43%), while a quarter of the respondents had just basic education as their highest level of education (25%). Only 15% of respondents had secondary level education. The finding on the level of education is not surprising because it is only recently that there has been increased enrolment in basic schools in Ghana, especially in the rural areas due to the implementation of national policies to improve enrolment in basic schools. Most farming communities were not given much attention in the past regarding basic education with a large part of the lives of people revolving around agriculture.

3.2. Crop cultivation and storage by farmers

Table 2 shows cereal crops cultivated by respondents. Two main cereal crops were found to be the most dominant in the municipality. They are maize and cowpea. Maize was however found to be the major cereal crop cultivated in the municipality (52%). Nevertheless, almost two-thirds (35%) of respondents cultivated both maize and cowpea.

In terms of storage, the study found that about half of the respondents (48%) store grains of between 6-10 tons per season, while a quarter of respondents (25%) store between 1-5 tons during every farming season. A few of the respondents do store grains above 10 tons per season. The size of cereal crops stored demonstrates that agricultural households are smallholder farming households. Further, the results show that, predominantly, the duration of grain storage among the farmers was in the range of 5-8 weeks (48%) and 9-12 weeks (35%).

3.3. Extent of adoption of hermetic storage bags for grain storage

Results in Figure 3 show that hermetic methods of grain storage were not only common but also predominantly used as the preferred storage method for cereal crops in the municipality. Indeed, 98% of respondents indicated that it is highly used. Regarding the other storage methods, the result indicates that chemical methods of grain storage is not being used anymore, with about 93% of respondents indicating that its usage was low. Similarly, traditional forms of grain storage such as open-air, use of sisal and jute storage bags, and underground pit were common storage practices but are now on the decline.

Providing some reasons for the preference for hermetic bags, a medium-scale farmer from Saboline in

ISSN-Internet 2197-411x OLCL 862804632

Table 2. Crop cultivation and storage durations

Variable	Categories	#	%
What type of grains do you cultivate?	Maize	93	51.7
	Cowpea	24	13.3
	Both	63	35.0
What quantity or average tonnage of grains do you store per season?	<1 ton	21	11.7
	1-5 tons	45	25.0
	6-10 tons	87	48.3
	>10 tons	27	15.0
How long do you store grains after harvest?	1-4 weeks	3	1.7
	5-8 weeks	87	48.3
	9-12 weeks	63	35.0
	13-16 weeks	24	13.3
	More than 16 weeks	3	1.7

Ejura points out that "*I usually sell my produce immediately after harvesting due to lack of space and means of storing my grain but with the introduction of the hermetic storage technology, I now sell my produce only when I need money*". A small-scale farmer, however, points out that "*I do not sell my crops in the market, so I still use the traditional method of storing my maize in the barn. I can't afford the price of the bag*". During the interview, the officials from the Agricultural ministry pointed out that, they discourage the farmers from using chemicals to store their grains due to the inherent problems associated with it like, misuse or wrong use due to illiteracy. One of the chemicals they use is phostoxin. This is supplied in tablet form of aluminium phosphide.

The study further sought to get more information regarding the adoption of hermetic storage methods among respondents. Table 3 shows that the majority of respondents use Purdue Improved Crop (PIC) bags. The qualitative interviews indicated that it was the most widely available hermetic bag, which was lower in price and offered much protection for their cereal crops. Informants indicated that the PIC bags offered much protection against physical damage to their crops and are also suited for storing grains. The study also further sought to find out the regularity of use of the PIC hermetic bags by farmers. The result shows that 60% of respondents opined that they often use the hermetic bags, while 25% of respondents opined that they sometimes used the bags. The rest pointed out that they scarcely use them.

Table 3 also shows that majority of farmers used the PIC bags to store maize (47%), while about a third of the respondents (37%) used PIC bags to store both maize and cowpea. Apparently, these are the two main cereal crops cultivated in the municipality. The majority of respondents opined that they use 100kg hermetic bags to store their cereals. Indeed, the capacity of a PIC bag differs depending on the scale of operation of the farmer or the one storing the grain.

3.4 Effectiveness of the use of hermetic bags for grain storage

This section evaluates the effectiveness of hermetic bags in reducing postharvest loss in the Ejura-Sekye-

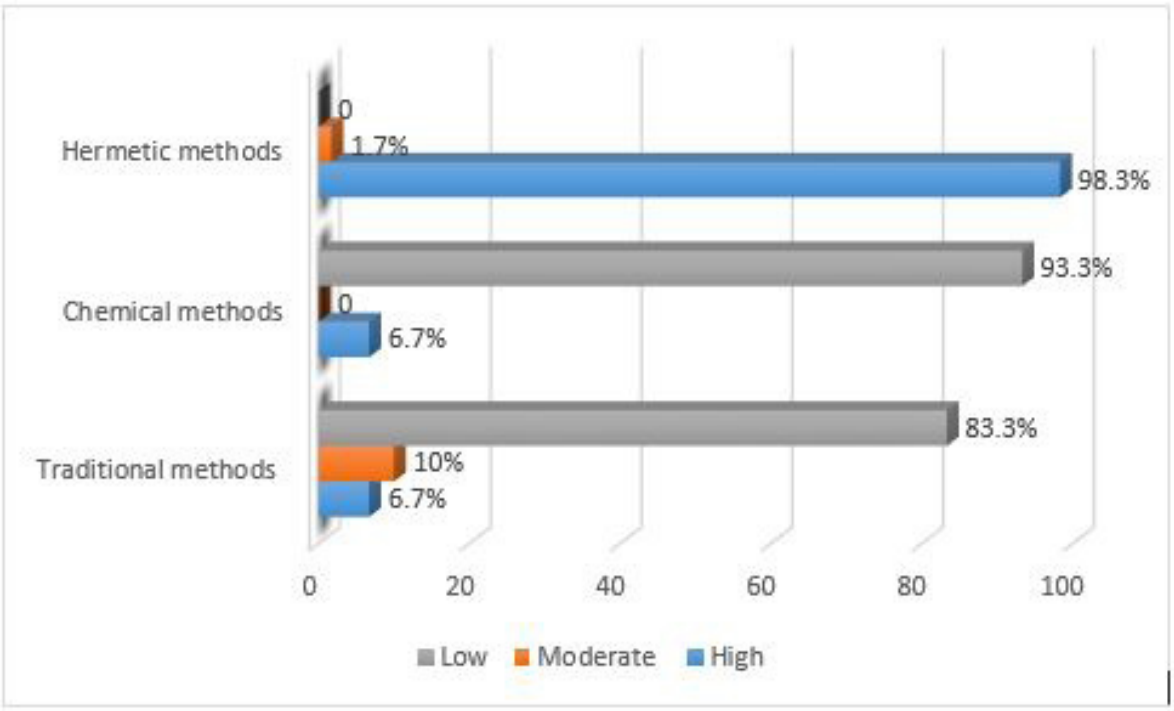

Figure 3. Main grain storage methods used by farmers.

Table 3. Types and usage level of hermetic storage bags by farmers

Variable	Categories	#	%
What types of hermetic bags do you use?	Super grin bag	15	8.3
	PIC	165	91.7
How often do you use the hermetic bags?	Often	108	60.0
	Sometimes	45	25.0
	Scarcely	27	15.0
Which type of crops?	Maize	84	46.7
	Cowpea	30	16.7
	Both	66	36.7
What size of the hermetic bags do you use?	50kg	15	8.3
	100kg	156	86.7
	150kg	9	5.0

dumase farming communities. The results shows that 98% of farmers reported that overall storage losses were low after using the hermetic storage bags (see Figure 4). Moreover, responses for improved seed viability were high (88%), suggesting that the use of hermetic bags indeed effectively reduces postharvest

ISSN-Internet 2197-411x OLCL 862804632

loss. The result also shows that grain damage was low following the use of hermetic storage bags (97%). Further, the responses show that the moisture level of stored grains in hermetic bags was also low (97%) as well as low pest infestation (92%) following the use of hermetic storage bags. Overall, the results clearly show that hermetic storage technology is potent in reducing postharvest loss in the municipality.

Figure 5 shows respondents' answers on postharvest losses of grains before the adoption of hermetic storage technology and after its adoption. The result shows that about 78% of the respondents reported high loss of grains before the adoption of the technology. This amounts to 8 out of 10 people reporting high losses, which is a significantly high figure. Thus, the result shows that postharvest loss of grains was a challenge to farmers prior to the adoption of the hermetic storage bags.

The situation of postharvest loss of grains seems to have plummeted following the introduction of hermetic storage bags. As can be observed from Figure 5, about 75% of respondents opined that postharvest loss of grains has reduced following the adoption of the hermetic bags. The finding shows the profound impact of the use of this technology. This point is corroborated by the quote below which provides insight into farmers' experience with the use of this new technology: According to Kofi, a participant in the study from Meminaso, "*The use of the bag helps to maintain the quality of the stored grains. The important thing I like about the bag is its ability to protect the cereal from rodents and moulds.*"

Respondents also highlighted how the use of hermetic storage bags has reduced exposure to insects and fungus. Indeed, an overwhelming 93% of respondents indicated that they have not experienced insect and pest infestation of grains following the adoption of the technology. This point was also corroborated by one farmer in Ejura-Saboline as captured in the quote: "*before I started using the PIC bags, I lost a lot of grains because of the insect and pest. Even when I kept the grains in a warehouse (using jute bags) there were some that got damaged as a result of pest infestations. But this time things have improved for me as I do not experience losses as a result of the use of this new technology*"

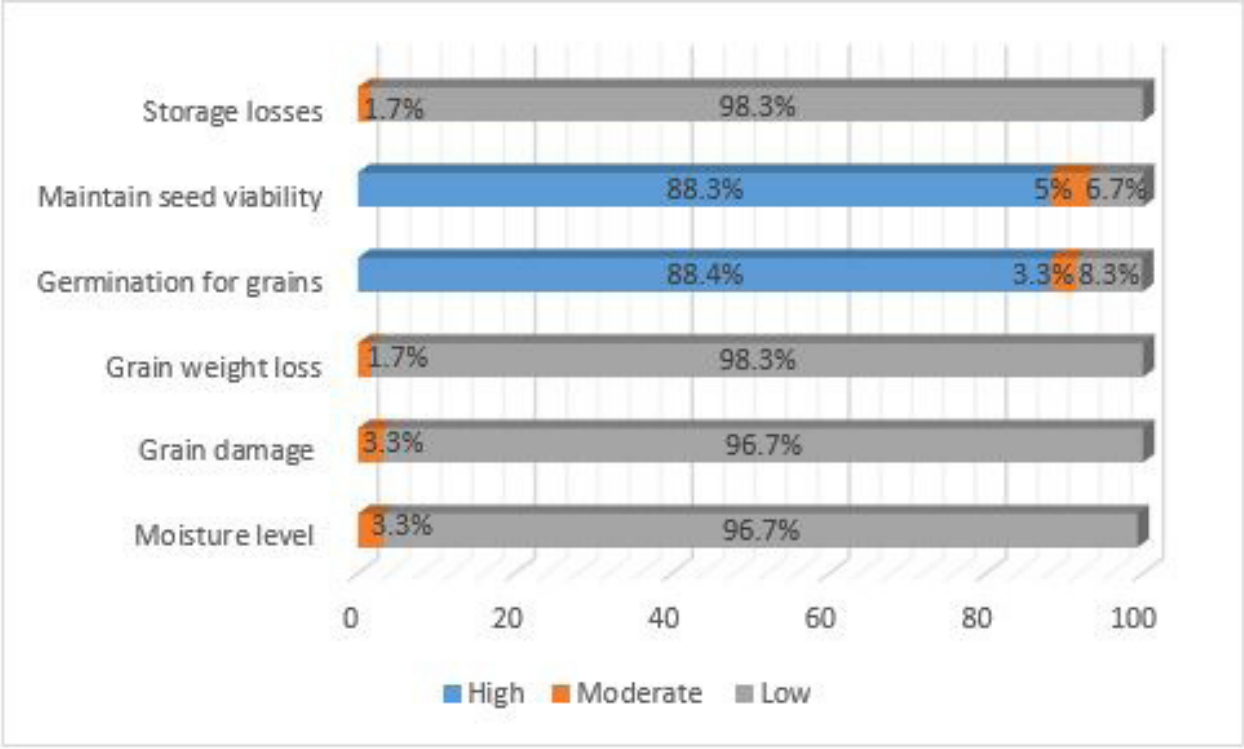

Figure 4. Effectiveness of hermetic storage technology in grain storage

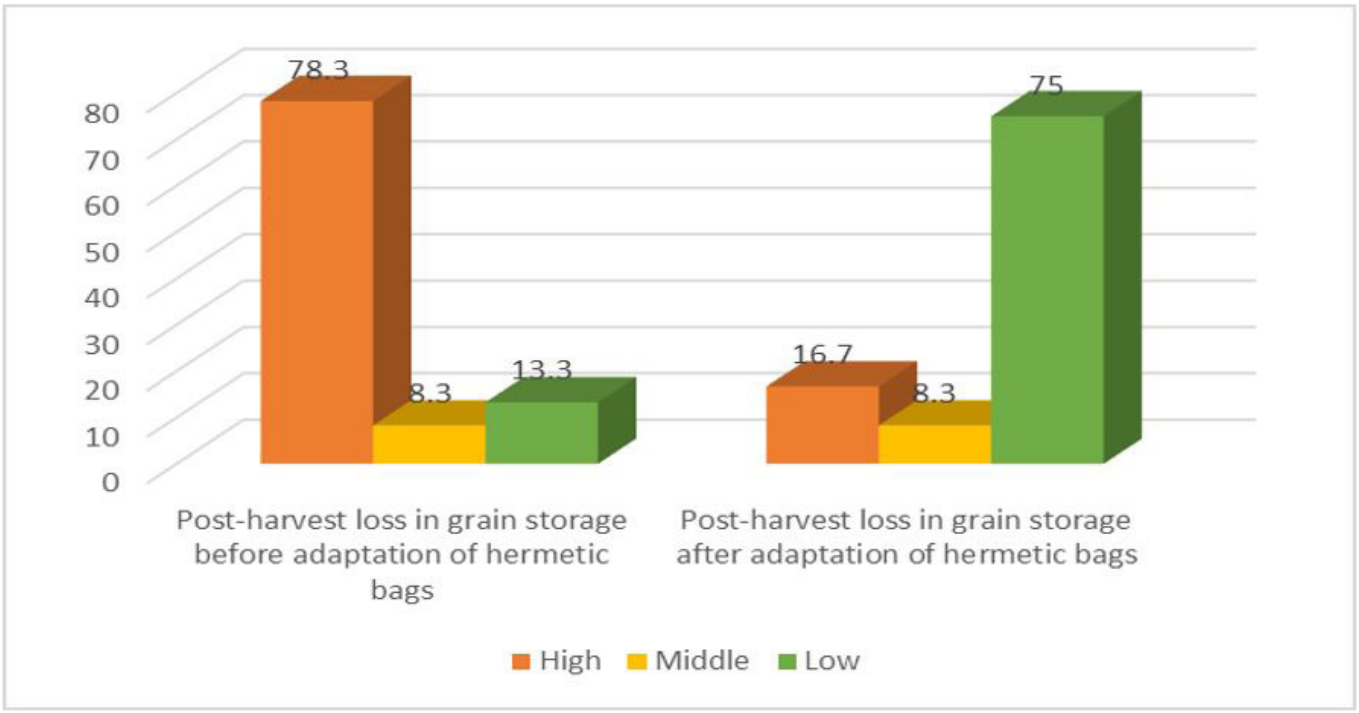

Figure 5. Postharvest loss of grain before and after the adoption of Hermetic bag

4. Discussions

Cereal crops constitute an important staple in the diets of many Ghanaians. Maize for instance constitutes about 80% of all staple foods consumed in the country. There is thus the need to increase its cultivation and yield to ensure food security. About 50% of rural households and 20% of urban households cultivate cereal crops under rain-fed agriculture (Quiñones & Diao, 2011). It is therefore not surprising to see majority of the respondents cultivating maize. Cowpea is also produced in all parts of Ghana due to its edible seeds that can be consumed by both humans and animals for protein. Cowpea production is strategic in Ghana due to its nutritional, agronomic, environmental, and economic advantages. It contributes to enhancing food security and the livelihoods of many households and the economy as a whole (da Silva et al., 2018). In addition to the above, the municipality as noted earlier has a favourable condition both climatically and topographically that makes it a hub for the cultivation of maize and cowpea. Its location in the sparse derived deciduous and middle-belt zone with savannah-like conditions provides a conducive ecological condition for the cultivation of many food crops including the two food crops in this study.

The study findings show that majority of farmers are moving away from using chemical and traditional methods of storing grains such as polythene bags, cribs, mud houses, and underground pits and are adopting hermetic storage bags. The findings thus contradict arguments by Obeng-Ofori (2010) that the use of traditional storage methods and chemical pesticides continue to dominate grain storage in most parts of Africa. Our findings similarly contradict Komen et al. (2006) who suggested that farmers in sub-Saharan Africa still adopt the traditional and chemical storage methods and techniques which are not effective to protect stored maize grains from storage losses. The findings from the study corroborates a recent study by Bandyopadhyay (2019) who argues that the adoption of hermetic bags for grain storage is increasing, and farmers are receptive to this new form of storage.

Results on the low usage of chemicals in storing grains indicate respondents' recognition of the harmful impact it has on their grains. This finding is well in synch with suggestions by Obeng-Ofori (2010) and Kimanya (2015) on the need to reduce the use of pesticides and other chemicals in storing grain crops. The main chemical used by farmers to store their grain before

ISSN-Internet 2197-411x OLCL 862804632

the large-scale introduction of the hermetic storage bag was in the form of dust, tablet, spray, or fumigant forms. Those in dust form were usually mixed with the grain when they were being bagged. The dust chemicals are the organophosphorus ones like actellic and pyrethroids. The tablets are wrapped and added to each bag of grain. The spray types are sprayed with knapsack machines on the layers of the bags to prevent insects from developing while the fumigants are used to kill insects in airtight containers like gallons or the crops are bagged with jute bags and covered with tarpaulins to make them airtight.

Indeed, the use of traditional storage methods and chemical pesticides have dominated grain storage in Africa (Adejumo & Raji, 2007; Obeng-Ofori, 2010) but the introduction of the hermetic storage technology is expected to gradually bring a shift from traditional and chemical storage methods to the adoption of the hermetic storage method as shown in our study. The findings here shows that the adoption of the hermetic storage method has been a conscious effort on the part of authorities, through extension services to create awareness of the new storage method (i.e., hermetic storage method). These efforts as were observed from interviews with officials from the Ministry of Agriculture in the municipal assembly[1] have paid many dividends, as evident by the extent of adoption. This current study is pointing out that, most farmers and maize marketers are now using improved methods of storage like hermetic devices. This suggestion resonates with Baributsa et al. (2010), who claimed that the adoption of the hermitic bag by farmers will contribute to improved farmers' incomes as well as increase the availability of high-quality, insecticide-free grains in the market. This implies that a key driver of the hermetic bag adoption is the gains that the farmer perceives to receive. Widespread adoption of this technology will assure food safety and security in the country. Let's not forget that food safety, especially the increased amount of aflatoxin in grains is a factor leading to the low export of Ghana's crops to neighbouring countries and abroad.

The three to four main types of hermetic storage bags which are in the market to be used by farmers include the Organic-Hermetic storage which is also known as the Purdue Improved Crop Storage (PIC), the Vacuum-Hermetic Fumigation" (V-HF), SuperGrain bags and Gas-Hermetic Fumigation (G-HF). In Ghana, two main brands of hermetic bags are being marketed. They are the Purdue Improved Crop Storage (PIC) bags and SuperGrain bags. The farmers in our study were noted to opt for the PIC bags. Due to the cost involved in the acquisition of these storage bags, farmers prefer the one that typically resembles their traditional method of storing grains, which is the 50kg supper grain bag which is the organic hermetic storage device. This finding corroborated Baributsa & Cristine (2020), who opined that PIC bag is very simple to use and low-cost which can be applied on a large scale to store maize and other cereal products by peasant farmers. It is only the plantation or large-scale farmers who can afford the other bag varieties due to their size. For instance, the Mega Cocoon and the TranSafeliner are big storage bags that can only be used by rich farmers. Even though a large proportion of farmers are using the small 50kg bags, not all farmers had the means to purchase these bags. This suggests that some farmers may still be using other means of storage which can derail efforts aimed at reducing postharvest loss and increasing farmers' income.

The main reason for using hermetic bags is their effectiveness in reducing postharvest loss. The main themes that emerged from this study are that farmers were able to decrease storage loss; maintain the viability of their seeds; increase the germination of the grains; decrease grain damage and decrease the moisture level of the crops as a result of the use of the hermetic bags. Authors like Donovan et al. (2019), Suleiman & Rosentrater (2015), and Obeng-Ofori (2010) all observed the benefits of using hermetic bags to store grain for future use. In effect, this finding is re-enforcing the claim that the use of hermetic storage bags improves the sustainability of grains (Donovan et al., 2019) and ensures that farmers are not fleeced off their income. The farmers are thus able to store the crops and sell them at higher prices during the lean season for profit. The use of the bag, therefore, reduces the reliance on 'middlemen' or 'market mummies' who have advanced means of storing the grains and reap heavy profit at the expense of the farmers. Compared with the traditional methods of storing grains,

[1] The municipal assembly is the local governing unit in the municipality. It comprises of the Municipal Chief Executive, administrative officials, and elected representatives of electoral areas in the municipality

once the grains are put in the airtight hermetic storage bags, even if there is an egg or larvae in the grain, as the days roll by, the oxygen in the sack would be used up. After the oxygen is gone, the insects cannot survive in the bags leading to their extinction. It should be noted that, the hermetic bags work perfectly well when seeds are well dried or to their storage moisture content level. If they are not well dried, moulds would likely develop leading to an increase in aflatoxins and the cereals would not meet the standard required in the market. The shelf life of stored grains is thus increased with this technology. This claim by farmers in our study is thus not new. What is new is its widespread usage to increase income and food security in the study area. This argument supports Fusseini (2015) who said that farmers who adopted the hermetic bag technology improved their food security and the income of their entire households due to the higher prices that they will get from selling their produce during the lean season. It is of interest to know that sustainable development goal two is to have zero hunger and this can be achieved through food security in the form of reducing postharvest loss. There are a lot of limitations in the agricultural processes and value chain in Ghana and the world at large. Combating postharvest loss is challenging however, widespread usage of hermetic storage bags can help fight hunger in Ghana and other countries as a whole. It was also found in this study that the use of hermetic storage bags by farmers is also leading to better income, which is the goal of sustainable development one. Better income comes with good health and well-being and all other goals will follow.

5. Conclusion

The study sought to address the following objectives: (1) examine the extent of adoption of hermetic storage bags for grain storage, and (2) examine the effectiveness of the use of hermetic bags for grain storage. The findings showed that the majority of respondents have shifted from using traditional storage methods like polythene bags, silos, mud houses, or use of cribs to widespread use of hermetic storage bags to store their crops. Regarding the effectiveness of hermetic storage bags, the study found that hermetic bags reduce postharvest losses by ensuring the sustenance of the quality of the grain, promoting longer shelf life, and preventing storage pests. Further, the effectiveness of hermetic storage bags resulted in the reduction of postharvest losses when compared to the past when respondents did not use hermetic storage bags. It can thus be concluded that, widespread adoption and use of good technology like the hermetic storage bags can help achieve most of the sustainable development goals like goal one-no poverty, goal two-zero hunger, goal three-good health and well-being, goal four-quality education, goal six-clean water and sanitation to mention only a few. The use of hermetic storage bags by farmers to store their grains will thus lead to sustainability. There is a need to increase training and sensitization activities for farmers to improve awareness and ultimately adoption. The more farmers are aware of the benefits and use of hermetic technology, the higher their level of adoption and use in the storage of grains. The study also found that the cost of hermetic bags is high, and the appropriate sizes for grain storage are not readily accessible in the Ejura-Sekyedumase Municipality. This greatly impedes the adoption of the technology and ultimately erodes the gains of reducing postharvest losses. Hence, the issues of affordability and availability of hermetic bags to farmers must be addressed by appropriate authorities. First, the Government of Ghana should subsidize the cost of hermetic bags to promote adoption and use among farmers. Second, agencies should assess farmer needs and provide appropriate hermetic bag sizes to farmers to facilitate adoption.

Conflict of Interests

The authors declare that there are no conflicts of interest in the gathering of data and preparation of this paper.

References

Asif, M., Rooney, L. W., Ali, R., & Riaz, M. N. (2013). Application and opportunities of pulses in food system: A review. Critical Review in Food Science Nutrition, 53(11):1168-1179. doi: 10.1080/10408398.2011.574804

Aboagye, D., Darko, J. O., & Banadda, N. (2017). Comparative study of hermetic and non-hermetic storage on quality of cowpea in Ghana. Chemical and Biological Technologies in Agriculture, 4(1), 10. doi: 10.1186/s40538-017-0091-y

ISSN-Internet 2197-411x OLCL 862804632

Adejumo, B. A., & Raji, A. O. (2007). Technical appraisal of grain storage systems in the Nigerian Sudan Savanna. Agricultural Engineering International: the CIGR Ejournal,9, 1–12. Retrieved from https://cigrjournal.org/index.php/Ejounral/article/download/966/960/960

Adjei-Gyapong, T., & Asiamah, R.D. (2002). The interim Ghana soil classification and its relation with the world reference base for soil resources. FAO, 98. Retrieved from https://agris.fao.org/agris-search/search.do?recordID=XF2003413695

Aulakh, J., Regmi, A., Fulton, J. R., & Alexander, C. E. (2013). Estimating post-harvest food losses: Developing a consistent global estimation framework; Proceedings of the Agricultural & Applied Economics Association's 2013 AAEA & CAES Joint Annual Meeting, 4–6. doi: 10.22004/ag.econ.150363

Bandyopadhyay, R., Atehnkeng, J., Ortega-Beltran, A., Akande, A., Falade, T. D. O., & Cotty, P. J. (2019). "Ground-truthing" efficacy of biological control for aflatoxin mitigation in farmers' fields in Nigeria: From field trials to commercial usage, a 10-year study. Frontiers in Microbiology, 10, 2528. doi: 10.3389/fmicb.2019.02528

Baributsa, D., & Ignacio, M. C. C. D. (2020). Developments in the use of hermetic bags for grainstorage. In Maier, D., Advances in postharvest management of cereals and grains. UK: Burleigh Dodds Science Publishing. doi: 10.19103/AS.2020.0072.06

Baributsa, D., Lowenberg-DeBoer, J., Murdock, L., & Moussa, B. (2010): Profitable chemical-free cowpea storage technology for smallholder farmers in Africa: Opportunities and challenges. Proceedings of the 10th International Working Conference on Stored Product Protection. Julius-Kühn-Archiv, 425. doi: 10.5073/jka.2010.425.340

Boxall, R.A. (2001). Post-harvest losses to insects—A world review. International Biodeterioration & Biodegradation, 48(1), 137–152. doi: 10.1016/S0964-8305(01)00076-2

Creswell, J. W. (2014). Qualitative, Quantitative and Mixed Methods Approaches (4th Ed.). Thousand Oaks, CA: Sage Publications.

Creswell, J. W. (2009). Editorial: Mapping the field of mixed methods research. Journal of Mixed Methods Research, 3(2): 95-108. doi:10.1177/1558689808330883

Creswell, J. W., & Plano-Clark, V. L. (2007). Designing and Conducting Mixed Methods Research. Thousand Oaks, CA: Sage Publications.

Donovan, N. K., Foster, K. A., & Salinas, C. A. P. (2019). Analysis of green coffee quality using hermetic bag storage. Journal of Stored Products Research, 80(9), 1–9. doi: 10.1016/j.jspr.2018.11.003

FAO (2019). The state of food and agriculture 2019: Moving forward on food loss and waste reduction. Retrieved from https://www.fao.org/3/ca6030en/ca6030en.pdf

FAO (2017). Policy measures for managing quality and reducing post-harvest losses in fresh produce supply chains in South Asian Countries. Retrieved from https://www.fao.org/3/a-i7954e.pdf

Ejura-Sekyedumase Municipal Assembly (2016). The Composite budget of the Ejura-Sekyedumase District Assembly for the 2016 fiscal year. Retrieved from https://esma.gov.gh/wp-content/uploads/2018/06/ESMA-Composite-budget-2016.pdf

Fusseini, I. (2015). Effectiveness of triple-layer hermetic bags against aflatoxins in stored maize. UG-Space. Retrieved from http://ugspace.ug.edu.gh/handle/123456789/8368?show=full

GSS (2013). 2010 Population and Housing Census. National Analytical Report. Retrieved from https://statsghana.gov.gh/gssmain/fileUpload/pressrelease/2010_PHC_National_Analytical_Report.pdf

GSS (2020). 2017/2018 National report of the Ghana census of agriculture. Retrieved from http://www.indiaenvironmentportal.org.in/content/468830/20172018-national-report-of-the-ghana-census-of-agriculture/

Grote, U., Fasse, A., Nguyen, T. T., & Erenstein, O. (2021). Food security and the dynamics of wheat and maize value chains in Africa and Asia. Frontiers in

Sustainable Food Systems, 4, 617009. doi: 10.3389/fsufs.2020.617009

Kimanya, M. E. (2015). The health impacts of mycotoxins in the eastern Africa region. Current Opinion in Food Science, 6, 7-11. doi: 10.1016/j.cofs.2015.11.005

Komen, J. J., Motoko, M. C., Wanyama, J., Rono, S. C., & Mose, L. O. (2010). Economics of Postharvest Maize Grain Loss in Trans Nzoia and Uasin Gishu Districts of Northwest Kenya. In: Proceedings of the 10th KARI Biennial Scientific Conference held 12–17 November 2006, in Nairobi, Kenya (pp. 1228–1233). Retrieved from https://www.researchgate.net/publication/262157107_ECONOMICS_OF_POST-HARVEST_MAIZE_GRAIN_LOSSES_IN_TRANS_NZOIA_AND_UASIN_GISHU_DISTRICTS_OF_NORTHWEST_KENYA

Obeng-Ofori, D. (2010). Residual insecticides, inert dusts and botanicals for the protection of durable stored products against pest infestation in developing countries. Julius-Kühn-Archiv, (425), 774. doi: 10.5073/jka.2010.425.141

Onwuegbuzie, A. J., & Leech, N. L. (2005). On becoming a pragmatic researcher: The importance of combining quantitative and qualitative research methodologies. International Journal of Social Research Methodology, 8(5), 375-387. doi: 10.1080/13645570500402447

Rajashekar, Y., Bakthavatsalam, N., Shivanandappa, T. (2012). Botanicals as Grain Protectants. Psyche: A Journal of Entomology. doi: 10.1155/2012/646740

Rajashekar, Y., Ravindra, K. V., & Bakthavatsalam, N. (2014). Leaves of Lantana camara Linn. (Verbenaceae) as a potential insecticide for the management of three species of stored grain insect pests. Journal of Food Science and Technology, 51(11), 3494–3499. doi: 10.1007/s13197-012-0884-8

SRID/MOFA (2016). Agriculture in Ghana: Facts and figure 2015. Retrieved from https://mofa.gov.gh/site/images/pdf/AGRICULTURE-IN-GHANA-Facts-and-Figures-2015.pdf

Sugri, I., Abubakari, M., Owusu, R. K., & Bidzakin, J. K. (2021). Postharvest losses and mitigating technologies: evidence from Upper East Region of Ghana, Sustainable Futures, 3, 100048. doi: 10.1016/j.sftr.2021.100048

Suleiman, R., & Rosentrater, K. A. (2015). Current maize production, postharvest losses and the risk of mycotoxins contamination in Tanzania. In 2015 ASABE Annual International Meeting. American Society of Agricultural and Biological Engineering. Retrieved from https://dr.lib.iastate.edu/server/api/core/bitstreams/92be2069-ff34-4e58-8a0e-2971abe0d9c3/content

da¬-Silva, A. C., da-Costa-Santos, D., Junior, D. L. T., da-Silva, P. B., Dos-Santos, R. C., & Siviero, A. (2018). Cowpea: A strategic legume species for food security and health. Legume Seed Nutraceutical Research. In Jimenez-Lopez, J. C., & Clemente, A., Legume Seed Nutraceutical Research. London, UK: IntecOpen. doi: 10.5772/inte chopen.79006

Quiñones, E. J., & Diao, X. (2011). Assessing crop production and input use patterns in Ghana–what can we learn from the Ghana Living Standards Survey (GLSS5)? International Food Policy Research Institute. Retrieved from https://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.227.442&rep=rep1&type=pdf

ISSN-Internet 2197-411x OLCL 862804632

UniKassel & VDW, Germany- July 2022