Ansah et al., *Cogent Food & Agriculture* (2018), 4: 1475916
https://doi.org/10.1080/23311932.2018.1475916

cogent food & agriculture

FOOD SCIENCE & TECHNOLOGY | RESEARCH ARTICLE

Effect of postharvest management practices on welfare of farmers and traders in Tamale metropolis and Zabzugu District, Ghana

Isaac Gershon Kodwo Ansah[1]*, Justice Ehwi[1] and Samuel Arkoh Donkoh[1]

Received: 13 March 2018
Accepted: 08 May 2018
First Published: 14 May 2018

*Corresponding author: Isaac Gershon Kodwo Ansah, Department of Agricultural and Resource Economics, Faculty of Agribusiness and Communication Sciences, Post Office Box TL 1882, UDS Nyankpala Campus, Tamale, Ghana
E-mail: agershon@uds.edu.gh

Reviewing editor:
Fatih Yildiz, Middle East Technical University, Turkey

Additional information is available at the end of the article

Abstract: Postharvest losses are a significant threat to the actors in the yam value chain. In this article, we examined the key postharvest management practices and its effect on the welfare of yam farmers and traders in selected towns of Northern region. We randomly sampled a cross section of farmers and traders for data collection, and analyzed the data with beta regression and linear regression models. Results show that farmers lose an average of 9.6% of stored yam in 2-month period, while traders lose 3.3% of yam stored in a month. The main postharvest storage-management practices used by farmers and traders include heat-control measures, sorting-management practices, and cleaning-management practices. Our regression results verify that good storage-management practices improves postharvest management, thereby reducing storage losses and enhancing the welfare outcomes for traders. However, no statistically significant effect was detected for

ABOUT THE AUTHORS

Isaac Gershon Kodwo Ansah, a lecturer at the Department of Agricultural and Resource Economics, UDS, holds master degree from Wageningen University and Research (Netherlands), and currently studying for his PhD in the same institution. His research interests encompass applied economics and econometric studies that have agricultural and food policy implications. Specifically, Isaac's interest borders on the nexus among shocks, coping/adaptation responses, and food security.

Justice Ehwi is currently a Teaching Assistant at the Department of Agricultural and Resource Economics of the University for Development Studies (UDS). Justice has a deep-seated interest in research, and intends to delve deeper into the microeconomics of postharvest losses, and general issues related to food security in developing countries.

Samuel Arkoh Donkoh (PhD) is an Associate Professor and Vice Dean at Faculty of Agribusiness and Communication Sciences, UDS. His research work falls in the domain of adoption, efficiency studies, and poverty analysis and also issues of economics and agriculture that require the application of econometric techniques and principles.

PUBLIC INTEREST STATEMENT

Many poor households in developing countries go hungry not because they produce less, but sometimes due to the amount of harvested food that goes waste. In fact, media information and scientific reports all attest to this speculation. Our hypothesis is that farmer-level practices can help to minimize, if not completely eliminate, postharvest losses. We investigate what mechanisms, in terms of management practices, that yam farmers and traders employ to reduce postharvest storage losses, and how these practices affect their welfare. We use data collected from a cross-section of farmers and traders from two districts in Northern region of Ghana. After the analysis of the data, we find that farmers and traders adopt practices that control heat in the storage structures, eliminate rotting, prevent attacks by rodents, among others. These practices, if effectively engaged, help some actors to improve food availability and their overall welfare.

farmers. Therefore, we suggest that information on and availability of improved postharvest storage-management practices should be delivered and fostered among farmers and traders in the study areas to maximize efforts aimed at reducing postharvest losses and improve welfare outcomes.

Subjects: Sustainable Development; Development Policy; Development Economics

Keywords: beta regression; postharvest management; postharvest storage losses; welfare

1. Background and problem

Low-income, food-deficit countries have become more worried about the global and national food situation over the years (World Bank, 2011). One important source of worry is the extent of postharvest food losses recorded in many developing countries. Therefore, food security will continue to be an issue as far as food production and distribution have not been well integrated with effective management of postharvest losses. Against this backdrop, Lipinski et al. (2013) question how the world's food production and postharvest management could sufficiently feed an estimated 9.5 billion people by 2050, and in a manner that advances social and economic development, while preserving the ecosystems. According to Bourne (2014), increasing food production without reducing the corresponding wastage is unsustainable. In this regard, Lipinski et al. (2013) advocate that improving food security would require that postharvest losses are managed effectively, coupled with increasing production. However, studies show that while increasing productivity has "opened-end" potential, postharvest loss reduction has a "closed-end" potential (Bourne, 2014). Simply said, food that can be recouped into the global food stock through postharvest loss management is more certain than what can be achieved by increasing food production.

In many African countries, yam is an important staple and a versatile crop, with relatively higher yields compared to cassava (Ogaraku & Usman, 2008), with broader agroecological adaptability, diverse maturity period, and in-ground storage capability (Sanginga & Mbabu, 2015). This puts the yam crop in an important position to help address food and nutrition security in Africa. Besides the economic importance, the social, cultural, and religious significance of yam is exhibited by being the preferred food in social gatherings (Osunde, 2008). Despite this position of yam in the socio-economic and cultural contexts in many African countries, its production in Africa is challenged by physical, biological, climatic, technological, and socioeconomic factors of which postharvest losses are considered dominant (FAO, 2009). Though over the years, effort is made to combat this problem, postharvest losses in tubers remain quite significant. For example, Lipinski et al. (2013) indicate that generally, about 23% of the world's food (roots and tubers) fails to reach the final consumer due to losses along the value chain. These tuber losses are attributed to factors that cause both quantitative and qualitative losses. According to Rosegrant, Magalhaes, Valmonte-Santos, and Mason-D'Croz (2016), physical damage, rodent attack, fungal and bacterial diseases, and physiological processes such as sprouting, dehydration, and respiration are the major drivers of high postharvest losses in Africa. Bourne (2014) andKc, Hague, Legwegoh, and Fraser (2016) also identify poor infrastructure and weak market systems that fail to connect potential buyers to producers as important causes of postharvest losses in Africa. The World Bank (2011) asserts that postharvest losses translate into low income and become a disincentive to investments and support service provision in farming. In addition, Moomaw, Griffin, Kurczak, and Lomax (2012) stress that food losses deplete the resource base used in production, and consequently influence the overall food available for consumption.

In fact, the story of postharvest losses in Ghana is no different, especially in Tamale and Zabzugu in northern region. Alhassan (1994) reported that postharvest losses of yam and cassava were 30% of the total crop. In 2012, Ghana recorded yam postharvest losses of 17.4% (MoFA, 2013). This still calls for attention to the issue of postharvest losses. Though poor infrastructure contributes to high postharvest losses in Africa, research shows that the human factors also account for a significant proportion of yam postharvest losses (Ansah, Tetteh, & Donkoh, 2017; Bourne, 2014). Specifically, Ansah and Tetteh (2016) reechoed the need to reduce postharvest losses as a key means to improve national food security. According to the authors, one way to reduce postharvest loss is to manage storage losses, and in this regard, effective postharvest management practices are key areas to be improved. It is anticipated that managing postharvest storage losses will allow commercially oriented farmers to store their produce for long enough without significant losses, which can motivate them to release output when market price is attractive. For farmers who aim at meeting food needs, reducing postharvest losses is a way to ensure food availability throughout the year.

In Ghana, due to poor infrastructure and poorly developed postharvest storage structures, meeting the objective of crop storage to await better prices or to meet food needs has been difficult for yam value chain actors to achieve. Specifically, yam farmers in the Zabzugu district of Northern region face low prices, especially at bumper harvests, but are still unable to effectively hold their produce for sale at lean seasons when prices are attractive due to high postharvest losses as reported in the District Composite Budgets (2016). On the other hand, yam traders in the Tamale metropolis have reported incidences of postharvest losses, which reduce their profits. Not only do yam postharvest losses affect the welfare of actors, it invariably affects the welfare of consumers through poor quality and high prices during lean seasons. The sinking impact of postharvest losses has equally not encouraged yam production or sale on commercial basis. For example, Halos-Kim (2013) outlines that due to high postharvest losses, subsistence agriculture still prevails and much processing is done at the family or household level, while the scaling up of operations by traders (especially by retailers and wholesalers) is yet another challenge. In addition, a report by FAO (2015) shows that as at 2013, more than a quarter of the Ghanaian population was still below the poverty line of US$ 1.25 or GH₵ 5.63 per day, and particularly in the northern region; meanwhile majority of these people below the poverty line are farmers. This means that effective postharvest loss management could be an entry point to help reduce poverty and hunger in the northern region where yam is one of the major crops widely produced and consumed.

To find a lasting solution to the incidence of postharvest losses, many empirical researches have surfaced. For example, existing empirical studies have quantified postharvest losses (Dapaah, 2013), or examined the human elements contributing to postharvest losses (Ansah & Tetteh, 2016), or analyzed the income effect of postharvest management (Adebamiji, 2011; Ansah et al., 2017). In addition, Hodges et al. (2011) identified that the challenge of postharvest losses can be solved through effective control of the losses. Meanwhile, from the point of view of Ansah and Tetteh (2016), effective control of food losses is a function of the human element. While these studies have contributed to our understanding of the postharvest loss menace, limited attention is given to the mechanisms by which postharvest storage losses could be reduced, especially in terms of the management practices, and how these practices could influence welfare outcomes. This knowledge gap is well echoed by Ansah et al. (2017), who advocate future research to investigate the key management practices and how these influence welfare. In this regard, the objective of this study is to examine how yam farmers in the Zabzugu district and traders in the Tamale metropolis manage postharvest losses and analyze whether and to what extent managing these losses translate into welfare outcomes.

The rest of the study is organized as follows. Section 2 discusses the data and analytical approach for addressing the questions raised in the preceding section, while Section 3 presents and discusses the results from the analysis. In Section 4, the article concludes with some policy implications. Finally, in Section 5 the limitations of the study are highlighted.

2. Methodology

2.1. Study area and data

The study covered the Tamale Metropolis and Zabzugu District in the Northern region of Ghana. Tamale, the capital city of the Northern region of Ghana, hosts about 371,351 people consisting of

50.1% females and 49.9% males. It is a nodal city that serves as convergence zone and the commercial hub of the three northern regions (Ghana Statistical Service [GSS], 2012). Tamale town is located 600 km north of Accra and at latitude 9° 24′ 27″ and longitude 0° 51′ 11.99″. On the other hand, Zabzugu district lies on latitude 9° 17′ 0″ North and longitude 0° 22′ 0″ East. It is one of the main yam producing areas where traders directly commute to various farm-gates for bulk purchases. The 2010 Population and Housing Census put the population of the district at 61,927 people with males being 49.3% and 50.7% females. Located in the savannah zone, the northern region is dominated by farmers who engage in single season farming due largely to the mono-modal rainfall pattern, with thinly dispersed vegetation and long period of Harmattan winds. The annual average, minimum, and maximum temperatures are 27.6°C, 21.6°C, and 33.0°C, respectively, while annual precipitation is 1,235 mm of rain.

We sourced data through a cross-sectional field survey of yam farmers and traders in the study areas. The data were collected within the months of February and March 2016 from the two study areas. Information asked included demographic and socioeconomic characteristics of farmers and traders as well as postharvest losses and management practices in yam. Specifically, the questionnaire captured information on the management practices relating to heat control measures, sorting measures, cleaning measures, rodents control, use of chemicals, among others. In addition, socioeconomic information relating to the age, education, access to credit, savings, and others were embedded in the questionnaire. A two-stage sampling technique was used to collect data on farmers and traders who engage in yam farming or trading and, where the incidence of postharvest losses is reported to be of concern. In this regard, we used a purposive sampling in the first stage to select one dominant district for yam farmers and another for traders. In the second stage, we used simple random sampling to select 100 farmers from four communities in Zabzugu district and 100 traders from two major trading centers in Tamale. From the four communities in the Zabzugu district, we sampled 15 farmers from Sheini, 11 from Lagbani, 25 from Nyamgbodor, and 49 from Zabzugu. These sample sizes were distributed based on the relative sizes of the communities. From the Tamale Metropolis, 50 traders each were sampled from the Aboabo market and Tamale Central market. The simple random sampling ensured that every member of the target population had a fair chance of being in the sample. Using standard questionnaire as a survey instrument, we conducted personal interviews to obtain information on the variables of interest from the selected respondents.

2.2. Data analysis

The extent of postharvest storage losses among famers and traders was quantified using mean scores, and the postharvest management practices that they use to control losses was summarized with tables. An Exploratory Factor Analysis (EFA) and regression techniques were used to model the determinants and effect of postharvest loss management on welfare. Several practices that are carried out before, during, and after yam storage were measured to assess how such practices contribute to managing postharvest storage losses.

To assess factors that influence PHM (defined as the ability of a yam value chain participant to reduce or minimize storage losses), the beta regression model was used. Following Ansah and Tetteh (2016), the dependent variable (PHM) was derived as the ratio of the quantity of stored tubers that remained unblemished to the total quantity of tubers that were stored, as follows:

$$PHM = \frac{Qunatity\ of\ yam\ tubers\ stored - Quantity\ of\ yam\ tubers\ lost}{Quantity\ of\ yam\ tubers\ stored}$$

The PHM coefficient is a proportion that lies between 0 and 1 (i.e., $0 \le PHM \le 1$). PHM measures the extent of effectiveness of yam farmer or trader in reducing postharvest storage losses. Larger values correspond to better ability of an actor to manage storage losses. A zero value means that the respondent experienced 100% storage losses and all the stored tubers went waste. On the other hand, PHM = 1 is an indication that a respondent never experienced any storage loss. Such a respondent is classified as very effective in managing yam postharvest storage losses.

2.2.1. Econometric model of the association between management practices and postharvest management

To model the effect of postharvest management practices on PHM, a beta regression was used because of the proportional nature of the dependent variable. Ferrari & Cribari-Neto (2004) and Baum (2008) demonstrate that using a proportional dependent variable in a linear regression would yield senseless predictions for extreme values of the regressors. Hence, a proportional dependent variable regression model is better suited for estimating the coefficients. Since the dependent variable assumes a beta distribution, a beta regression becomes more flexible and efficient for estimating the coefficients (Ferrari & Cribari-Neto, 2004). However, the mean responses are expected to lie within the bounded unit interval. Therefore, an appropriate functional form is used to transform the dependent variable so that it imposes constraints and ensures that the predicted values lie within the unit interval (Papke & Wooldridge, 1996). Thus, it becomes necessary to transform the model as in Equation (1) below.

$$g(\mathrm{PHM}) = (\chi_i{}'\beta) = n_i \tag{1}$$

where g is a nonlinear distribution function that transforms the model to ensure that the predicted values of the dependent variable lie within the bounded unit interval. The coefficients of the model are estimated using maximum log-likelihood estimator (MLE). The MLE requires that both a link and distribution functions are specified. The parameters in the model are obtained by maximizing the log-likelihood function for beta regression model to take the form of Equation (2).

$$\begin{aligned}\log L(\theta) = \sum_{i=1}^{N} & w_i \log\Gamma(\varphi) - w_i \log\Gamma(x_i{}'\theta\varphi) - w_i \log\Gamma[(1 - x_i{}'\theta)\varphi] + w_i(x_i{}'\theta\varphi - 1)\log PHM_i \\ & + w_i[(1 - x_i{}'\theta)\varphi - 1]\log(1 - PHM_i)\end{aligned} \tag{2}$$

where PHM is the dependent variable, N denotes sample size, **X** is a matrix of independent variables for a farmer or trader, w_i is an optional weight, ø is the precision parameter, and Γ is the gamma link function. The link function Γ(·) follows a logit distribution such that model (2) turns into Equation (3) below.

$$g(\chi_i{}'\beta) = \frac{e^{\chi_i{}'\beta}}{1+e^{\chi_i{}'\beta}} \tag{3}$$

Therefore, the empirical specification of the beta regression model via GLM is expressed as shown in Equation (4).

$$PHM = b_0 + \sum_{k=1}^{3} b_k M_k + \sum_{j=4}^{6} b_j X_j + e \tag{4}$$

where b_k and b_j are coefficient vectors to be estimated; e represents a random error term; M are postharvest management storage practices, and X are control variables. The explanatory variables and the expected signs of their coefficients are presented in Table 1.

2.2.2. Econometric modeling of postharvest management and welfare

To assess whether an improvement in postharvest storage loss management would contribute to better welfare outcomes of yam value chain actors, we used PHM as a principal explanatory variable and controlled for other variables. A measure of welfare consists of the count of assets owned by a farmer or trader. Welfare so obtained was regressed on PHM and the control variables using linear regression techniques. We assumed welfare to satisfy the basic fundamental assumptions that permit the use of ordinary least squares (OLS) as the estimator for the parameters of interest. Welfare (Y) is expressed as a function of PHM and control factors incorporated in Equation (5) and reported in Table 2.

Table 1. Measurement and a priori expectation of variables used in the postharvest management and welfare functions

		A priori expectation	
Variable	**Definition and measurement**	***Postharvest management function***	***Welfare function***
Heat control (M_1)	Score of postharvest management practices used to reduce heat accumulation in storage structure	+	
Sorting (M_2)	Score of postharvest management practices used to sort yams	+	
Cleaning (M_3)	Score of postharvest management practices used to ensure hygiene in storage structure	+	
Postharvest management (PHM)	Ratio of total unspoiled tubers to total stored tubers		+
Age	Measured in years	+	±
Education	Years spent in formal education	+	
Household size	Count of people in a house that feed from the same pot	+	±
Access to credit	Dummy, 1 if yes, 0 if no	+	+
Savings	Dummy, 1 if respondent saves with a bank, 0 if not	+	
Scale of operation	Number of yam tubers a farmer produced, or a trader bought in the season	±	+
Sale-point	Distance from residence to market where produce is sold or to farm where yam is produced	−	
Land	Dummy, 1 if participant owns land and 0 if participant does not	+	+

Notes: + indicates a direct effect and − indicates an indirect effect.

$$E(Y|PHM;X) = b_0 + b_1PHM + b_1X_1 + b_2X_2 + b_3X_3 + b_4X_4 + b_5X_5 + b_6X_6 + e \quad (5)$$

where PHM has its usual connotation, X's are the control variables, and e is an independently and identically distributed random error with mean zero and constant variance.

3. Results and discussion

3.1. Distribution of postharvest management practices among yam farmers and traders

During the field survey, it was noted that 89% of the sampled farmers and all the traders adopted some form of management practices to reduce postharvest storage losses. The remaining 11% of the farmers mentioned that due to factors such as small harvest volume, risk of losing produce through theft and high postharvest losses they had experienced in the past led them not to store any produce in the season under recall. Table 2 provides a summary of postharvest management practices adopted by farmers and traders in the study areas.

Table 2. Distribution of yam postharvest storage loss management practices among farmers and traders

	Farmers		*Traders*	
Management practices	**Frequency**	**Percentage**	**Frequency**	**Percentage**
Store yam with bruises and cuts separately from clean ones	89	89	100	100
Arrange yam in storage house according to size and variety	88	88	75	75
Spray storehouse before storage	0	0	0	0
Provide aeration in the storage structure regularly	0	0	71	71
Inspect storage structure for insects/pests attacks on tubers to identify affected tubers	61	61	38	38
Protect stored yam from excessive heat and sunshine	46	46	97	97
Check and remove bruised and affected yam before storage, and those in storage that are sprouting or rotting	84	84	97	97
Mark and separate bruised yam from clean ones in the storage structure	75	75	44	44
Rodents control	89	89	100	100
No management practice	11	11	0	0

Because there are several practices undertaken by respondents to manage postharvest losses, we used EFA to reduce these practices into reasonable number of attributes that exhibit no multicollinearity. Such reduced number of aspects was then used in the regression analysis. Using the EFA, three key attributes were inferred from the various practices (see Table 3). These three attributes explain about 60% of variance accounted for.

As reported in Tables 2 and 3, the most widely used management practices belong to those associated with cleaning. Respondents usually separate bruised yam tubers from clean ones before storage. During storage, respondents also undertake regular inspection in the storage structure to remove bruised, sprouted, or rotten tubers from the clean ones. Furthermore, respondents also store bruised yam tubers separately from the clean ones in the storage structure. Besides cleaning management practices, many farmers and traders also sort out yams by way of arranging the yam tubers according to size (small and large) and varieties (white yam, yellow yam, and water yam) in the storage structure. In addition, during storage, many farmers and traders regularly inspect for insect or pest infestations, and separate affected ones from clean ones. For those tubers that are affected, they are marked and kept separately form the clean tubers. Such practices ensure that yam tubers are always sorted so that affected tubers can easily be identified from the clean tubers. According to the respondents, sorting practices do not only help to reduce storage losses but also facilitates the sale of yam tubers, with higher probability of commanding attractive prices.

Another central set of postharvest management practices are classified into heat control measures. These measures involve regular provision of aeration in the storage structure, further protecting the stored tubers from excessive sunshine by covering with thatch or similar materials that absorb less heat, and periodically removing old yams from the storage

Table 3. Factor analysis and classification of main postharvest management practices into attributes

	Unrotated solution			Oblimin rotated solution			
Postharvest management practice	***Factor 1***	***Factor 2***	***Factor 3***	***Factor 1***	***Factor 2***	***Factor 3***	**Uniqueness**
Store yam with bruises and cuts separate from clean ones		0.3979	0.7428			0.7876	0.3693
Periodically inspect and remove old yams from the storage structure	−0.4991	0.6961	0.3146	0.6995			0.4939
Arrange yam in storage structure according to size and variety		0.4815			0.6688		0.4509
Provide aeration in the storage structure regularly	−0.6168	0.5445		0.7816			0.3767
Protect yam from excessive heat and sunshine while in storage	0.5710			0.7462			0.4076
Check and remove bruised and affected yam before storage, and tubers in storage that are sprouting or rotting	−0.6858					0.8088	0.3449
Inspect storage structure for insects/pests attacks on tubers to identify affected tubers			0.7857		0.7811		0.3737
Mark and separate bruised yam from clean ones in the storage structure	0.6446	0.4576			0.7578		0.3701
Model characteristics							
Eigenvalue of factor	1.96634	1.49685	1.35004	1.75798	1.67405	1.38125	
Proportion of variance explained by factor (%)	24.58	18.71	16.88	21.97	20.93	17.27	
Factor classification and naming							
Factor 1 consists of measures that control heat in the storage structure. It is, therefore, called *heat-control* management practices.							
Factor 2 involves measures that involves sorting/separation of yam tubers. We, therefore, assign the name *sorting* management practices.							
Factor 3 basically involves separating bruised yams from clean ones to avoid contamination or microbial infection of clean tubers. We, therefore, assign the name of *cleaning* management practices.							

barn to prevent sprouting and respiration. These measures tend to be very important as most traders undertake the practices. Surprisingly, none of the respondents sprayed their storehouse before stocking with newly harvested or purchased yams. The reason for this was not apparent, but a possible explanation could be that there are no toxic-free chemicals available for postharvest management or participants might have limited knowledge about existing ones. After yams are packed in the storage barns, farmers and traders further undertake routine management practices to avoid or at least minimize yam-storage losses. Among these practices, the least used is ensuring adequate airflow in the storage structure (i.e., aeration). About 71% of traders undertake this practice but no farmer does it. These farmers indicated that they are not able to provide aeration because their yam tubers are normally stored on the farm. Hence, if doors or vents of the huts are opened in their absence, this could attract pests and rodents or even theft. Respondents indicated that despite these management practices, and intense heating, rodents and pests attacks seem to increase postharvest losses in yam.

3.2. Distribution of yam postharvest storage losses among farmers and traders

Yam postharvest storage losses recorded by farmers in Zabzugu district and traders in Tamale metropolis during the 2015/2016 production season are quite significant considering the storage volumes and duration. From the analysis, all respondents recorded storage losses. The results are shown in Tables 4 and 5, respectively.

The results show that, on average 61 yam tubers (equivalent to GH₵ 150 or about US$ 38) were lost by farmers after 2 months of storage. This represents 9.6% of the average quantity of tubers (approximately 638 tubers of yam) stored during the 2-month period. Thus, for every 100 tubers of yam stored by farmers about 10 tubers are lost after 2 months period. On the other hand, traders lose an average of 16 tubers of yam (equivalent to GH₵ 45) after a month. The differences in the storage duration is because traders usually store the commodities for few weeks and sell, while farmers often store the produce for a long time, usually anticipating better prices in lean seasons. Therefore, for traders only 4 tubers are lost per 100 tubers of stored yam in 1 month. However, the overall losses of yam recorded by respondents are relatively high and significant, considering the amount lost in currency unit equivalence. In addition, if we consider that farmers and traders are in different parts of the same yam value chain, then it means that summing these losses at the production side and trading side shows significant postharvest losses.

According to the responses from farmers and traders during the field survey, the most important factors that lead to losses of tubers are poor storage structures, excessive heating (which hastens the process of respiration and decomposition) and attacks by insects and rodents. Among these factors, the most worrisome is the attacks by insects and rodents that cause physical losses (about 95% of all

Table 4. Distribution of yam postharvest losses by farmers for 2015/2016 production season (storage duration = 2 months)

Tubers lost	Frequency	Percentage	Min	Max
1–50	51	57.3	7	50
51–100	23	25.84	52	100
101–150	10	11.24	103	150
151–200	3	3.37	155	200
Above 200	2	2.25	203	209
Total	**100**	**100**	**0**	**2000**

Note: The overall average losses of yam tubers among farmers is 61.35 tubers of yam.

Table 5. Distribution of yam postharvest losses by traders for 2015/2016 production season (storage duration = 1 month)

Tubers lost	Frequency	Percentage	Min	Max
1–10	27	27	5	10
11–20	50	50	11	20
21–30	17	17	21	30
31–40	4	4	31	37
Above 40	2	2	41	47
Total	**100**	**100**	**0**	**2000**

Note: The overall average losses of yam tubers among traders is 16.04 tubers of yam per month.

respondents stated this). Therefore, there is the need for improved storage methods and management practices in Zabzugu district and Tamale metropolis, and perhaps other yam-producing communities in Ghana.

3.3. Summary statistics and mean comparison of variables used in the models for farmers and traders

In Table 6, we compare farmers and traders on the variables used in the regression models using mean comparison test.

The postharvest management capacity among yam famers in Zabzugu district and traders in Tamale metropolis is averagely good. The mean PHM values indicate that farmers and traders are about 92% and 97% efficient in managing postharvest storage losses, respectively. The difference in the PHM values of farmers and traders is statistically significant at 5% level. Since traders and farmers apparently use different inputs in managing postharvest losses, this statistic may suggest that the inputs used in managing storage losses play significant role in reducing losses. As reported in Table 7, majority of farmers and traders sort out their yams by sizes and varieties before packing into the storehouse. In addition, it is evident that respondents undertake management practices (e.g., ensuring aeration, protecting tubers from excessive heating, and removing old yams from hut or storehouse) that prevent heat build-up in the storehouse.

From the survey, majority of yam farmers and traders (about 68% of farmers and 75% of traders) were unable to read or write due to lack of formal education. Also, while majority of yam farmers store their produce on the farm as a mechanism to reduce labor and transportation costs, most traders store yams in sacks or in congested and unimproved storage structures at the marketing site. Scale of operation is also large despite the significant losses recorded by participants. This is understandable because yam production and trade remains the main livelihood activities of the respondents involved in the survey. Therefore, with improved structures and management practices, storage losses could significantly be reduced, and yams could store for longer periods to help achieve household food security and maximize profit.

Access to information on postharvest management practices as well as access to credit is undesirably low. Specifically, only 33% of farmers and 36% of traders had access to credit in the

Table 6. Model variables and mean comparison for yam farmers and traders

Variable	Mean for farmers (μ_1)	Mean for traders (μ_2)	*P* value (t) for H_0: $\mu_1 = \mu_2$ at 95%	Conclusion
Age (years)	40.72	41.48	0.5483	Not differ
Education (years)	2.84	2.48	0.5648	Not differ
Household size	8.59	5.73	0.0000	Differ
Scale of operation	1050.16	889.3	0.0066	Differ
PHM score	0.92	0.97	0.0000	Differ
Heat-control	0.45	0.85	0.0000	Differ
sorting	0.81	0.57	0.0000	Differ
Cleaning	0.93	0.93	0.8734	Not differ
Years in school	2.84	2.50	0.4468	Not differ
Land ownership	0.79	0.35	0.0000	Differ
Sale point	2.13	4.38	0.0000	Differ
Savings account	0.43	0.52	0.0735	Not differ
Access to credit	0.33	0.36	0.5270	Not differ
Information on PHM	0.55	0.03	0.0000	Differ

Table 7. Marginal effects from fractional logit regression (dependent variable is PHM)

	Traders		*Farmers*	
Variable	**Marginal effect (%)**	**Std. error**	**Marginal effect (%)**	**Std. error**
Age	−0.00	0.0001658	−0.00	0.0008282
Education	−0.03	0.0002524	−0.07	0.0009945
Household size	−0.06	0.0008334	0.09	0.0022148
Information on PHM	−0.67	0.0053317	2.11**	0.0095986
Sale point	−0.02	0.0006795	0.49	0.0047723
Land ownership	0.78***	0.002302	1.56	0.0117383
Scale of production/ marketing	1.72***	0.0021114	−1.51*	0.0086563
Access to credit	−0.22	0.0032495	−0.49	0.0142808
Savings account	0.33	0.0024154	1.45	0.0157014
M1	2.17***	0.0067202	5.41***	0.0207508
M2	1.93***	0.0038533	5.23***	0.0148541
M3	2.01**	0.0064081	−5.93	0.0464641

Notes: (**) and (***) indicate 5% and 1% significant levels, respectively.

previous growing season. This might be a challenge, especially to the resource poor farmer or trader, in acquiring necessary inputs for managing postharvest losses. Furthermore, the mean comparison tests indicated no statistical differences between the average ages, cleaning management practices, education, and access to credit of yam farmers and traders. On the other hand, there exist statistical differences in household size, scale of operation, PHM, heat control, sorting, and access to PHM information as reported in Table 6 in the *t* test column.

3.4. Effects of management practices and control factors on postharvest storage loss management

We estimated two separate functions: one for farmers and the other for traders because these actors tend to operate under different systems. Therefore, pooling the data together may not be appropriate and could hide certain peculiar characteristics of traders or farmers. The beta regression model results are reported in Table 7. The column titled "marginal effect" measures the direction and extent to which a unit change in an independent variable would influence PHM. For example, when the scale of marketing increases by 1%, the ability of a trader to manage postharvest storage losses increases by 1.72%, holding all the other variables constant. In other words, the volume of yam produce handled by traders significantly influences the level at which traders can effectively control yam postharvest losses.

Out of the 12 explanatory variables that were hypothesized to influence PHM, 5 were found to exert significant effect in the trader model, and 4 in the farmer model. Specifically, all the three postharvest management practices were statistically significant for traders while two (i.e., heat control and sorting management practices) were statistically significant for farmers. For the control variables, only scale of production was statistically significant in both models; land ownership was significant only in the trader model, while access to information on PHM was statistically significant only in the farmer model.

As reported in the table, the extent of heat control (M1) was found to have a clear influence on PHM. A percentage point improvement in the score of heat-control-management practices reduces storage losses significantly and, therefore, improves postharvest management of traders by 2.17%, all other things equal. This conforms to the a priori expectation. The effect is even larger for farmers, where we find that a percentage point improvement in the score of heat-control-management practices increases postharvest management by a significant 5.42%, *ceteris paribus*. This result confirms the findings of Bourne (2014) that excessive heating promotes rapid respiration and decomposition of commodities in storage, and especially those of higher moisture content and, therefore, shortens their shelf life.

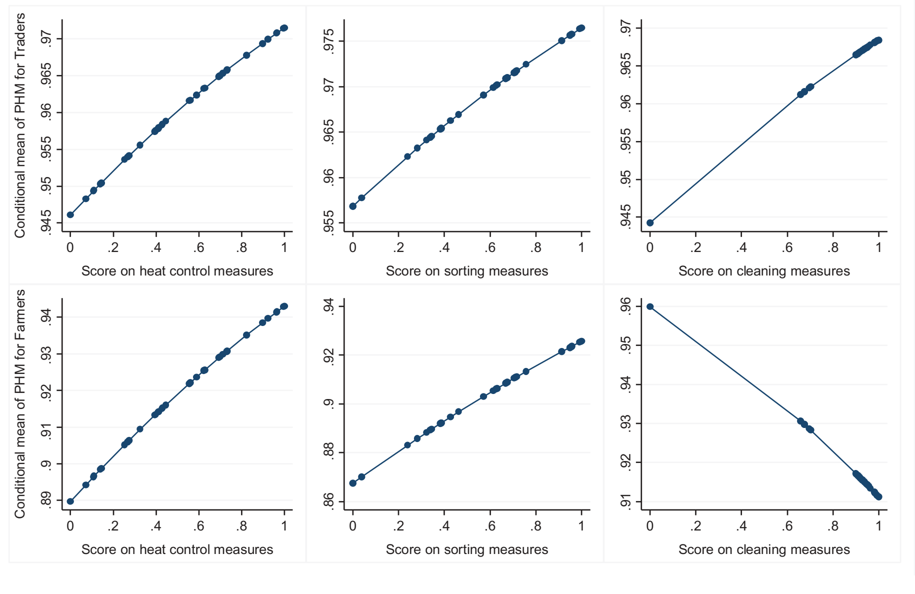
Similarly, sorting management practices (M2) have significant effects on postharvest storage loss reduction for both traders and farmers. Traders who undertake sorting measures effectively are able to reduce storage losses and, therefore, improve postharvest management by 1.93%. On the other hand, if sorting management practices improves by one percentage point, farmers are able to improve postharvest management practices by 5.23%, other things held constant. This result meets expectation, and it throws more light on the findings by FAO (1998) and Osunde (2008) on the general rule of product storage. The rule implies that, if yam is stored according to size and variety, it helps provide good selective strategy such that varieties of poor storage capacity can be sold or consumed first, while varieties of good storage capacity can be stored for longer periods, thereby contributing positively to storage loss reduction.

Again, while cleaning management practices (M3) had statistically significant influence on storage loss reduction in the trader model at the 5% level, surprisingly there was no statistical influence on postharvest storage loss reduction in the farmer model. The farmer model results refute expectation. However, we could imagine that only 3% of farmers had access to information on postharvest management practices. Such a distribution could affect the way in which cleaning management practices were done among farmers.

To gain a better understanding of the nature of the association between these management practices and PHM, we used the Royston (2013) *marginscontplot* (or mcp) command in Stata to further assess how changes in the scores of the management practices engaged by farmers and traders influence the marginal effects of PHM (see Figure 1).

The marginal effect plots indicate that as farmers and traders improve on the scores of heat control and sorting management practices, PHM increases and hence are able to reduce storage losses. On the other hand, while increasing scores on cleaning measures improves PHM for traders, it rather tends to decrease the PHM of farmers. This is quite surprising and the reason cannot be immediately deciphered from the data.

Figure 1. Marginal effects of postharvest management practices on PHM from a beta regression model.



The extent to which scale of operation influences postharvest management is significant and positive for traders but negative for farmers. For the traders, a 1% increase in the quantity of yam purchased and marketed or traded increases the ability to manage postharvest losses by 1.72%, while for farmers it leads to a reduction in postharvest management by 1.51%, other things equal. Thus, farmers with higher production volumes tend to experience greater storage losses. Traders usually dispose of their purchased commodities readily especially where demand is high. Thus, traders that purchase more produce may also tend to have the inputs and structures to manage storage losses. However, larger farmers may have limited storage structures and other inputs needed to store the produce effectively. On the field, it was observed that most of these structures are traditional unimproved huts, which have obvious storage limitations. These structures are built by farmers themselves, and with higher production, it may become uneasy for such farmers to get adequate and well-built structures to manage the losses. The consequences are the relatively large storage losses recorded by these farmers, which translate into lower postharvest management.

Land ownership surprisingly also tends to enhance traders' ability to manage postharvest losses, but has no influence for farmers. A plausible explanation for the trader model is that the land may serve as an asset or collateral, which could be leaned on to solicit inputs for managing postharvest losses. In the case of farmers, their lands are their major productive assets. Hardly do farmers use their lands as collateral, for fear of not being able to redeem from credit providers.

3.5. Welfare effect of postharvest management

We further assessed how PHM influences a welfare proxy using ordinary least squares (OLS) regression. We control for other factors such as age, education, scale of operation, household size, land ownership, and credit access. The model performed relatively well, with R^2 value of 44.77% in the trader model and 36.51% in the farmer model (see Table 8). We find that PHM significantly influences only the welfare of traders but not farmers. In addition to PHM, land ownership is the only control variable that significantly influences the welfare of both farmers and traders.

The statistically significant positive coefficient of PHM in the trader model implies that a percentage point increase in postharvest management increases welfare of traders by a drastic 12.71%, controlling for other factors. This result conforms to the a priori reasoning that as postharvest management improves, a yam value chain actor would be able to reduce losses significantly. In this case, traders with better ability to reduce storage losses can professionally

Table 8. Effect of postharvest management on welfare of farmers and traders

	Traders		***Farmers***	
Variable	**Coefficient**	**Std. error**	**Coefficient**	**Std. error**
PHM	12.71***	2.069157	−0.067	0.6377559
Age	0.004	0.004535	−0.001	0.0029679
Education	−0.021	0.044024	0.081	0.0457255
Scale of operation	−0.037	0.056424	0.117	0.0504072
Household size	−0.053	0.147718	0.101	0.0562329
Land ownership	0.311***	0.069342	0.326***	0.0777692
Credit access	−0.087	0.070837	−0.042	0.0605610
Model diagnostics				
R^2	44.77%		36.51%	
Number of observations	100		92	
F statistic	10.65		6.90	
P value > *F* statistic	0.0000		0.0000	

Note: *** indicates significance at 1% level.

hold their output in wait for more rewarding prices. This can increase profit or ensure food security at the household level. Adebamiji (2011) and Ansah et al. (2017) reported similar findings for farmers in their respective studies. The insignificant relation between PHM and welfare reported in the farmer model could be attributed to a number of issues. First, we infer from the descriptive statistics that only 3% of farmers had access to information on postharvest management. This could imply that the kind of practices that farmers used were practically similar, and the differences were not adequate to translate into different welfare levels among the farmers. An implication of this result is the need to make available PHM information and offer proper training that could help improve the knowledge base of farmers on proper postharvest management practices. Second, in the PHM function we find that cleaning management practices rather had a negative effect on PHM. Thus, these measures would, therefore, increase storage losses, and may offset the positive effects exerted by the heat control and sorting management practices.

Finally, the land ownership coefficient shows the difference in welfare between farmers and traders who own land and those that do not. The value is similar in magnitude and direction for both traders and farmers. These values indicate that welfare of traders is about 0.31% better when they own land; for farmers, landowners have about 0.33% better welfare than nonowners of land.

4. Conclusion and policy implications

Postharvest storage loss reduction attracts policy attention due to the apparent benefits to be derived from such actions. In this study, we aimed to contribute to the postharvest loss reduction debate by examining the major postharvest management practices that yam farmers and traders engage, and whether these practices yield net benefits for these actors. We randomly sampled a cross section of farmers and traders for data collection and analyzed the data with beta regression and linear regression models. Results show that farmers lose an average of 9.6% of stored yam in 2-month period, while traders lose 3.3% of yam stored in a month. The main postharvest storage-management practices used by farmers and traders were classified into heat-control measures, sorting measures, and cleaning measures.

Heat-control measures include providing aeration in the storage structure regularly, protecting yam from excessive heat and sunshine while in storage, and periodically inspecting and removing old yams from the storage structure. Sorting management practices involve arranging yam in the storage structure according to size and variety, inspecting storage structure for insects/pests attacks on tubers to identify affected tubers, and marking and separating bruised yam from clean ones in the storage structure. For the cleaning management practices, respondents were identified to be storing yam with bruises and cuts separately from clean ones, and checking and removing bruised and affected yams before storage, and tubers in storage that are sprouting or rotting. Findings indicate that the management practices are indeed critical in reducing storage losses. More importantly, interventions that help to improve these management practices have greater potential to contribute to reducing storage losses along the yam value chain.

In terms of welfare effects, traders who adopt effective management practices experience increased welfare; however, no statistically significant effect was reported for farmers. Nonetheless, respondents remarked that poor storage structures and inadequate information on postharvest management practices, especially for farmers, are the major challenges that limit their abilities to engage in proper postharvest storage management. Therefore, improvement in the traditional storage methods coupled with improved management practices would motivate yam farmers and traders to store their produce during bumper harvest in anticipation of better prices during lean seasons when prices are attractive.

As a policy and investment advice, we suggest that farmers and traders construct spacious and well-ventilated huts or storehouses to reduce storage losses, since heat-control measures positively and significantly reduce storage losses. In addition, sorting is found to reduce storage losses; therefore, effort should be made to separate damaged tubers that occur through cuts, injuries, and bruises during handling from the clean tubers. Yam value chain actors must be trained and encouraged to store yam tubers by size and variety to increase shelf life. Finally, any intervention to improve the welfare of yam farmers and traders must consider measures or technologies that facilitate heat and rodent control to reduce postharvest storage losses.

5. Limitations of the study

First and foremost, our analysis provides a basis to further explore the critical postharvest management practices that farmers and traders employ to reduce storage losses. We have been able to establish a (causal) effect of these management practices on postharvest management and storage-loss reduction, through a good empirical framework, combining factor analysis and regression models. While this is an important step, and in the right direction, certain factors that could serve as limitations to the study findings and generalizations of results need to be pointed out. First, we acknowledge the restrictions of the sample size used in the study. While the pooled data could boast of a good sample size (200 respondents in all), a disaggregation into the occupational groups (farmers and traders) places some limits on the sample size. Second, our welfare measure also has important drawbacks, and that could explain why we observed no statistically significant effect of PHM on farmers' welfare. We used a count of assets as a proxy for welfare. Normally, in the rural settings of Ghana, smallholder farmers in particular are relatively homogeneous in terms of assets ownership. For example, almost everyone owns a bicycle, a motorbike, a sprayer, among others. By simply counting these assets and using it as a welfare measure, the likelihood that there would not be statistically significant variation is very high. In econometric modeling, we need variation in data to measure effects. Traders involved in this study are in the city, where lifestyles are relatively heterogeneous and asset ownership varies. Therefore, future study should look for a better measure of welfare (possibly, based on extensive multidimensional welfare measure) to analyze the true effect of PHM. Third and finally, in the first stage of the sampling design, the interest in yam postharvest management meant that a purposive sampling was used to select two dominant districts that produce or trade in yam. Such a sampling design does place a limit on the extent to which our findings could be generalized. Future study could adopt a purely random sampling approach at all stages of the research design stage in order to enhance generalizations of the research findings.

Funding
The authors received no direct funding for this research.

Competing interests
The authors declare no competing interests.

Author details
Isaac Gershon Kodwo Ansah[1]
E-mail: agershon@uds.edu.gh
ORCID ID: http://orcid.org/0000-0001-5071-6224
Justice Ehwi[1]
E-mail: ehwijust1990@gmail.com
Samuel Arkoh Donkoh[1]
E-mail: sdonkoh@uds.edu.gh
[1] Department of Agricultural and Resource Economics, Faculty of Agribusiness and Communication Sciences, University for Development Studies, Tamale, Ghana

Citation information
Cite this article as: Effect of postharvest management practices on welfare of farmers and traders in Tamale metropolis and Zabzugu District, Ghana, Isaac Gershon Kodwo Ansah, Justice Ehwi & Samuel Arkoh Donkoh, *Cogent Food & Agriculture* (2018), 4: 1475916.

References

Adebamiji, A. (2011, March). Effects of post-harvest losses on income generated in citrus spp in ife adp zone of Osun state, Nigeria. *African Journal of Food Science and Technology (ISSN: 2141-5455)*, *2*(3), 52–58. Retrieved from http://www.interesjournals.org/AJFST

Alhassan, A. Y. (1994). *Postharvest aspects of Yam and Cassava in Ghana*. Unpublished consultancy report, Ghana Ministry of Agriculture/GTZ (18 p).

Ansah, I. G. K., & Tetteh, B. K. D. (2016). Determinants of Yam postharvest management in the Zabzugu district of Northern Ghana. *Advances in Agriculture*, *2016*, 1–9. doi:10.1155/2016/9274017

Ansah, I. G. K., Tetteh, B. K. D., & Donkoh, S. A. (2017). Determinants and income effect of yam postharvest loss management: Evidence from the Zabzugu district of Northern Ghana. *Food Security*, *9*, 611–620. doi:10.1007/s12571-017-0675-1

Baum, C. F. (2008). Stata tip 63: Modeling proportions. *The Stata Journal*, *8*(2), 299–303. Department of Economics, Boston College, Chestnut Hill, MA.

Bourne, M. C. (2014). Food security: Postharvest losses. In N. K. V. Alfen (Ed.), *Encyclopedia of agriculture and food systems* (pp. 338–351). Oxford: Academic Press.

Composite Budget. (2016). *Composite budget for the Zabzugu district assembly for the 2016 fiscal year*. Zabzugu: Author.

Dapaah, K. P. (2013). Assessment of postharvest losses of yam production in the Karachi-East district of the Volta Region of Ghana. Kwame Nkrumah University of Science and Technology, Kumasi, Ghana.

FAO. (1998). *Prevention of postharvest losses in root and tuber storage: Food and agriculture organization of the United Nations*. Food and Agriculture Organization, Rome.

FAO. (2009). *The special challenge for sub-Saharan Africa*. Rome: Food and Agricultural Organisation of the United Nations.

FAO. (2015). *Country fact sheet on food and agriculture policy trends*. Ghana: Food and Agriculture Organization of the United Nations. Rome.

Ferrari, S., & Cribari-Neto, F. (2004). Beta regression for modelling rates and proportions. *Journal of Applied Statistics*, *31*(7), 799–815. doi:10.1080/0266476042000214501

Ferrari, S, & Cribari-Neto, F. (2004). Beta regression for modelling rates and proportions. *Journal of Applied Statistics*, *31*(7), 799-815.

Ghana Statistical Service. (2012). *Population & housing census: Summary report of final results*. Accra: Author.

Halos-Kim, L. (2013). Strategies to improve the adoption of postharvest handling and agro-processing technologies in Africa. *Ethiopian Journal of Applied Sciences and Technology (Special Issue No.1)*, *41*, 41–50. *Overview Paper*.

Hodges, R. J., Buzby, J. C., & Bennett, B. (2011). Postharvest losses and waste in developed and less developed countries: Opportunities to improve resource use. *The Journal of Agricultural Science*, *149*, 37-45.

Kc, K. B., Haque, .I, Legwegoh, A. F., & Fraser, E. D. (2016). Strategies to reduce food loss in the global south. *Sustainability*, *8*(7), 595.

Lipinski, B., Hanson, C., Lomax, J., Kitinoja, L., Waite, R., & Searchinger, T. (2013, June). *Reducing food loss and waste* (World Resources Institute Working Paper). Washington, DC, USA.

MoFA. (2013). *Agriculture in Ghana, facts and figures*. Accra: Statistics, Research and Information Directorate.

Moomaw, W., Griffin, T., Kurczak, K., & Lomax, J. (2012). *The critical role of global food consumption patterns in achieving sustainable food systems and food for all. A UNEP discussion paper* (p. 6). Paris: United Nations Environment Programme, Division of Technology, Industry and Economics.

Ogaraku, A. O., & Usman, H. O. (2008). Storage rot of some yams (Dioscorea spp.) in Keffi and environs of Nasarawa state Nigeria. *Production and Agricultural Technology*, *4*, 22–27.

Osunde, Z. D. (2008). Minimizing postharvest losses in yam (Dioscorea spp.): Treatments and techniques. In Gordon Robertson & John Lupien (Eds.), *Using food science and technology to improve nutrition and promote national development* (pp. 76–119). International Union of Food Science & Technology.

Papke, L. E., & Wooldridge, J. M. (1996). *Econometric methods for fractional response variables with an application to 401 (K) plan participation rates*. East Lansing, MI: Department of Economics, Michigan State University.

Rosegrant, M. W., Magalhaes, E., Valmonte-Santos, R. A., & Mason-D'Croz, D. (2016, July 31–August 2). *Returns to investment in reducing postharvest food losses and increasing agricultural productivity growth*. Selected paper prepared for presentation at the 2016 Agricultural & Applied Economics Association Annual Meeting, Boston, MA.

Royston, P. (2013). marginscontplot: Plotting the marginal effects of continuous predictors. *The Stata Journal*, *13*(3), 510–527.

Sanginga, N., & Mbabu, A. (2015). Root and tuber crops (cassava, yam, potato and sweet potato). In *Proceedings of the an action plan for African agricultural transformation conference* (pp. 21–23), Dakar, Senegal: International Institute of Tropical Agriculture.

World Bank. (2011). *Missing food: The case of postharvest grain losses in sub-Saharan Africa* (Tech. Rep. 60371—AFR). Washington, DC: Author.