Socio-Economic Determinants of Post-Harvest Losses in the Grape Value Chain in Dodoma Municipality and Chamwino District, Tanzania

Mary Kulwijila[†]

Abstract

Determinants of post-harvest losses (PHLs) in fruits are categorized into biological and environmental. While these are well known and have been discussed by numerous authors, the socio-economic determinants of PHLs are not empirically known. This study analysed the socio-economic determinants of post-harvest losses in grapes along the value chain. A cross-sectional research design was used to collect data from 246 grape farmers and 30 traders who were randomly selected from a list consisting of grape farmers and traders obtained from District Agricultural Irrigation and Cooperative Officers (DAICOs) of the study area. The results from multiple linear regression show that unreliable market, lack of credit, age of grape at harvest, quantity of grapes harvested and experience are the major statistically significant determinants ($p<0.05$) that influenced the post-harvest losses of grapes at farm level. At traders level, the quantity handled, time grape stay in market before sold and distance from the farm to the market positively and significantly ($p<0.05$) influenced post-harvest losses of grape. It is concluded that socio-economic determinants greatly influence PHLs of grapes in the study area. Based on the conclusion, the study recommends for interventions by the Government and other stakeholders in grape processing industries to broaden the range of products from grapes through value addition to reduce PHLs and enhance market for grapes. The study recommends further that credits be provided to grape farmers and traders to enable them buy modern post-harvest handling facilities including packaging and storage in order to reduce the losses.

Keywords: Determinants; Socio-economic; Grape; Post-harvest losses; Value chain; Dodoma
JEL Classification Codes: Q11; Q12; C21

[†] Department of Economics, University of Dodoma, P.O. Box 1208 Dodoma, TANZANIA.,Email: kulwijila@ymail.com; Cell: +255 784 771 271

1. Introduction

Fresh fruits and vegetables (FFVs) are essential sources of vitamins and minerals for humans (Verma and Singh, 2004). The quality and nutritional worth of fresh produce is affected by post-harvest handling and storage conditions which eventually cause post-harvest losses (Sablani *et al.*, 2006; Alidu *et al.*, 2016). However, post-harvest storage and loss prevention strategies in developing countries such as Tanzania are still negligible as compared to primary production related activities (Bachman and Earles, 2000; Basappa *et al.*, 2001; Bari, 2004; Kitinoja and Al-Hassan, 2012; Abass *et al.*, 2014; Ngowi and Selejio, 2019).

The estimates of post-harvest losses of FFVs vary widely across countries depending on the crop, season, and post-harvest management practices undertaken (Kodwo *et al.*, 2016). For example, post-harvest losses of fruits and vegetables are estimated to be 20-40 percentage in developing countries (Barry, 2009; Kumrul *et al.*, 2010; Atanda *et al.*, 2011; FAO, 2012; Kereth *et al.*, 2013; Vishal *et al.*, 2014; Kughur *et al.*, 2015; URT, 2017; Ngowi and Selejio, 2019). More specifically, post-harvest losses of banana, citrus, grapes, apples, avocado, and papaya were reported to be 20-80, 20-95, 53, 14, 43 and 40-100 percentage respectively in the developing countries (Rajabi *et al.*, 2015; Kughur *et al.*, 2015). Among the reasons for these high losses is the perishable nature of these crops (FAO, 2011).

Tanzania has favourable climate for growing different fruits and vegetables some of which are the sources of livelihood and income for many people (Kereth *et al.*, 2013). Grape is among the fruits grown in Tanzania, especially in Dodoma region (MAFS, 2006; Hussein, 2010). Tanzania, as is the case with many other developing countries, is faced with post-harvest losses of fruits and vegetables along their value chains (URT, 2002). The losses are influenced by many factors/determinants ranging from growing conditions to handling at consumer level (Ngowi and Selejio, 2019). Among the factors there are also biological, chemical, mechanical, psychological, physiological, physical and environmental factors (Kader, 2005; Kitinoja, 2010; World Bank *et al.*, 2011; FAO, 2011; Atanda *et al.*, 2011; Msogoya and Kimaro, 2011; Kereth *et al.*, 2013).

Despite the fact that these factors are well known in the literature and many technologies have been developed to reduce these losses, they have eventually not been succeeded. This was due to little attention paid to socioeconomic determinants contributing to post-harvest losses of fruits and vegetables in Tanzania and elsewhere (Kader, 2005). According to Klink (2015), to achieve a sustainable positive impact in reducing post-harvest losses (PHLs) in developing countries (DCs), the socio-economic determinants should be the basis for any development strategy to increase success rates.

Besides, the studies that have investigated socio-economic determinants influencing post-harvest losses of fruits and vegetables (Babalola *et al.*, 2010; Ayandiji and Adeniyi, 2011; Mbuk *et al.*, 2011; Aidoo *et al.*, 2014), have focused on vegetables and mainly tomatoes. The few studies on fruits have focused mainly on bananas (Adewumi *et al.*, 2009; Mebratie *et al.*, 2015). Little has been documented on post-harvest and determinants of losses of grapes. This study therefore analysed socio-economic determinants that influence grape losses along its value chain in Dodoma Municipality and Chamwino District of Dodoma Region of Tanzania. The outcome of the study is

expected to add knowledge on the determinants of post-harvest losses in grapes, assist in formulating appropriate policies and strategies for post-harvest losses management.

The remainder of this study is organized as follows. Section 2 reviews the literature on post-harvest loss; Section 3 presents methodology of the study, section 4 presents results and discussion and section 5 presents conclusion and policy implications.

2. Literature Review

2.1 Theoretical Literature: Conceptual Framework

Post-harvest loss (PHLs) refers to quantitative and qualitative losses of fruits along the value chain from harvest to consumption (Hodges *et al.,* 2011; Babu *et al.,* 2014). The literature on post-harvest aspects provides the theoretical links between post-harvest losses and the factors influencing such losses. The factors are grouped into those relating to biological, chemical, mechanical, psychological, physiological, physical and environmental factors (Kader, 2005; Kitinoja, 2010; World Bank *et al.,* 2011; FAO, 2011; Atanda *et al.,* 2011). All these factors affect the quality of the product which reaches the final consumers thus contributing to total PHLs of fruits at different stages along the value chain (Kikulwe *et al.,* 2018). The present study focused on the socio-economic factors/determinants that influenced the total grape losses at farm, wholesale and retail levels in the grape value chain which have not empirically studied.

The socio-economic determinants such as age of the respondents, education, distance from the farm to the market, the quantity harvested/purchased, the age of grape at harvest and experience in grape farming and trading were hypothesized in this study to influence grape losses both positively and negatively at farm, wholesale and retail levels. Other socio-economic factors include storage facilities, credit access, reliable market, family size, time grape spent on farm before being transported to the market and the time grape spent on market before sale as shown in Figure 1.

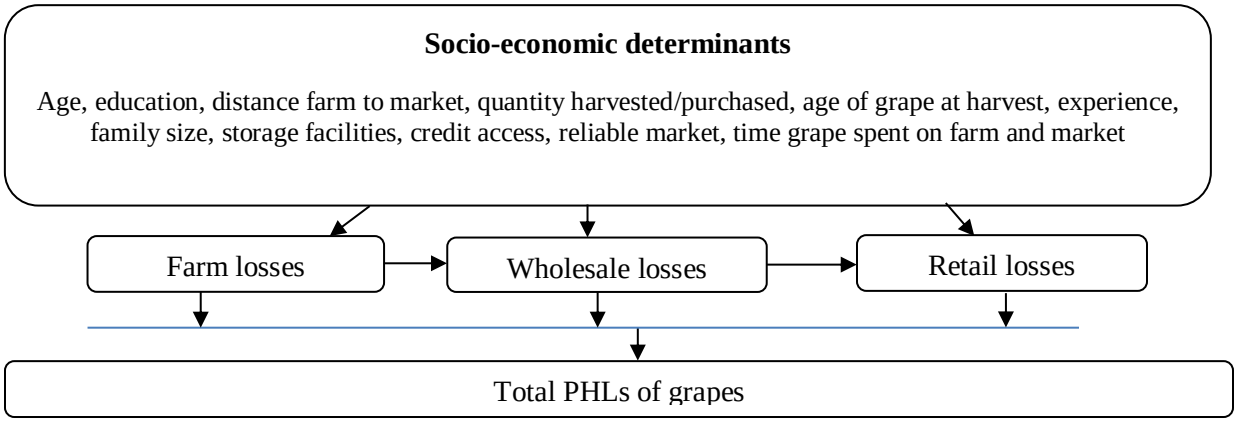

Figure 1: Conceptual framework on the determinants of grape losses

2.2 Empirical Literature

Empirical literature on grape losses and their determinants is very scanty. However, available literature focuses on other perishable agricultural commodities such as tomatoes, bananas, and fish. Few studies used economic models to evaluate the influence of different socio-economic factors on post-harvest losses in fruits and vegetables at farm and market levels (Mbuk *et al.*, 2011; Addo *et al.*, 2015; Ummar *et al.*, 2015 and Mebratie *et al.*, 2015). For example, Mbuk *et al.* (2011) observed that all management practices employed by retailers in the market to reduce losses increased the probability of spoilage except for the practice of covering the tomatoes on the table with paper. Other sources of income and the number of times the produce were cleaned weekly significantly influenced the extent of spoilage experienced by retailers. However, the number of days tomato spent on the farm before being transported to the market as well as the number of days tomato spent in the market before being sold was not analysed.

Ummar *et al.* (2015) found that, experience, picking time, and picking method had significant effects on the losses at farm level; whereas experience, loading method, storage place showed significant effects on the losses at the wholesale market level; and the unsold quantity and the type of retailers were significant determinants of the losses at a retail level. However, factors such as credit access, reliable market, and quantity harvested were not included in the study as part of the socio-economic factors contributing to PHLs.

Similarly, Addo *et al. (*2015) found that, socio demographic factors such as age, gender and literacy levels are important in determining the loss level. Literacy levels affect the level of skills, participation and innovativeness of an individual in managing, developing, and adopting new technologies. This study however, did not investigate whether family size of the respondent had any influence on tomato losses. Thus, in view of the reviewed literature, no study was found to have assessed the influence of socio-economic determinants such as credit access, reliable market, family size, distance farm to market, education, age of grape at harvest, the time grape spent on farm, and farming/trading experience on grape losses using multiple regression model in the study area.

3. Methodology

3.1 Analytical Model

According to different scholars (Kader 2005; Kumar *et al.*, 2006; Basavaraja *et al.*, 2007; Adewumi *et al.*, 2009; Atanda *et al.*, 2011, Aulakh, 2013; Mebratie *et al.*, 2015), total PHLs are influenced by a number of factors, ranging from growing conditions to handling at consumer level. In examining the influence of different factors on post-harvest loss of grape at farm and traders level, the Cobb-Douglas production function was used for estimating the coefficients of these factors. In a general form according to Hossain and Miah (2009) and Chong (2015), Cobb Douglas production function can be written as follows: -

$$Y_i = \beta_{0i} X_{1i}^{\beta_1} X_{2i}^{\beta_2} +, \dots, + X_{ni}^{\beta_n} e^{\varepsilon} \quad (1)$$

Where Y_i is the dependent variable (total PHLs in grapes for i^{th} respondent), β_0, β_1- β_n = are parameters to be estimated, X_{1i}- X_{ni} = values of the explanatory variables associated with the i^{th} respondent and ε = error term assumed to follow normal distribution with mean equal to zero and

constant variance σ^2. Equation 1 was converted in its log-linear form to obtain the linear relationship between the dependent variable and the explanatory variables as presented in equation 2. Similar model were employed by Kumar *et al.* (2006); Adewumi *et al.* (2009); Hossain and Miah (2009), Adepoju, (2014) and Mebratie *et al.* (2015)

$$LnY_i = ln\beta_0 + \beta_1 lnX_1 + \beta_2 lnX_2 +, \ldots., + \beta_9 lnX_9 + \varepsilon \quad (2)$$

Where Y_i is the dependent variable (total PHLs in grapes for i^{th} respondent), β_0, β_1- β_9 = are parameters to be estimated, X_1- X_9 = values of the explanatory variables associated with the i^{th} respondent (determinants of grape losses in this study the socio-economic determinants) and ε = error term assumed to follow normal distribution with mean equal to zero and constant variance σ^2. It is hypothesized that the level of PHLs of grapes is influenced by reliability of market (Market), access to storage facilities (Storage) and access to credit (Credit). Equation 3 specifies the linear relationship between level of PHLs and the three variables.

$$Ln\beta_{0i} = \varphi_0 + \varphi_1 Market + \varphi_2 Storage + \varphi_3 Credit + U_i \quad (3)$$

Where: $\varphi_1 Market$ = market dummy ('1' if unreliable and '0'otherwise), $\varphi_2 Storage$ = Storage facilities dummy ('1' if use storage facilities and '0' otherwise), $\varphi_3 Credit$ = Credit access ('1' if had access to credit and '0'otherwise) and U_i= error term. Substituting equation 3 into 2 gives equation 4 as follows: -

$$LnY_i = \varphi_0 + \varphi_1 Market + \varphi_2 Storage + \varphi_3 Credit + \beta_1 lnX_{1i} +, \ldots, + \beta_6 lnX_{6i} + \varepsilon_i + U_i \quad (4)$$

Therefore, from equation 4 the regression equation used in this study at farm and traders level was presented as:

$$LnY_i = \varphi_0 + \beta_1 lnX_1 + \beta_2 lnX_2 + \varphi_1 Market + \beta_3 lnX_3 + \beta_4 lnX_4 + \varphi_2 Storage + \varphi_3 Credit + \beta_5 lnX_5 + \beta_6 lnX_6 + V_i \quad (5)$$

Where: Ln = Natural logarithm, Y_i = Post-harvest loss of grapes for i^{th} respondent). The independent variables were age of respondent (years), education level of the respondent (years), $\varphi_1 Market$ = market ('1' if unreliable and '0'otherwise), quantity of grape harvested/purchased, age of grape at harvest (months), $\varphi_2 Storage$ = Storage facilities ('1' if use storage facilities and '0' otherwise), $\varphi_3 Credit$ = Credit access ('1' if had access to credit and '0'otherwise), distance farm to market, time grape spent on farm before transported to market, time grape spent on market before sold, experience in grape farming/trading (years), family size (number of persons), φ_0 = Constant and $\beta_1, \ldots, \beta_9$ are parameters to be estimated and V_i = Error term ($\varepsilon_i + U_i$).

3.2 Study area and Research design

The present study was conducted in Dodoma Municipality and Chamwino District of Dodoma region. The two districts were purposively selected because they are the leading districts in respect of grape production in the region. A cross-sectional research design was used in this study because a researcher intended to collect data related to PHLs of grapes at one point in time from farmers and traders respectively.

3.3 Sampling procedure and Sample size

The population of interest constituted smallholder grape farmers and traders. The sampling units were farmers and traders engaged in the production and trading of red grapes respectively. Only farmers who had started harvesting grapes were considered during the sampling process because the study was much concerned with PHLs. A two stage random sampling was adopted in this study. At the first stage, six villages were sampled randomly from a list consisting of villages cultivating grapes obtained from District Agricultural Irrigation and Cooperative Officers (DAICOs) of Dodoma Municipality and Chamwino District. The villages selected were Mpunguzi, Mbabala, and Hombolo in Dodoma Municipality and Mvumi Mission, Mvumi Makulu, and Makang'wa in Chamwino District. These villages were selected because are among the villages with high proportion of farmers and their potentials in grape production. In the second stage, 246 respondents were then randomly selected. The sample size was arrived at using a formula by Conchran (1974) as follows:

$$n = Z^2 \times p \times q/e^2 \quad (6)$$

Where n is the sample size; Z is the standard normal deviation set at 1.96 corresponding to 95% confidence level, p is the estimated proportion of an attribute that is present in the population (i.e., the proportion of grape farmers' in the area that was found to be 20% according to districts statistics), q = 1 – p and e is the level of precision (an error of 5%). Thus,

$$n = 1.96^2 \times 0.2 \times 0.8/0.05^2 = 245.86 \quad (7)$$

Based on the Conchran formula, the calculated sample size was 246 respondents for easy distribution of the respondents in the sample. However, the sample size used in analysis was 240 because other questionnaires did not capture information on post-harvest losses and so they were not involved in the analysis.

On the other hand, Dodoma grape assembly market near the former bus stand was purposively selected as the study site for grape traders, both wholesalers and retailers. This was due to the fact that most of the grapes produced were sold in this market. Traders who handled more than 2 tonnes of grapes per week were considered as wholesalers and those with less than 2 tonnes as retailers. Thus, using the list of 60 registered local traders from the two districts and with the help of Trade and Marketing District Officers, thirty (30) grape traders were randomly selected which included 15 wholesalers and 15 retailers and interviewed at their premises to elicit information on post-harvest losses using separate structured questionnaires. Thus, this made a total of 276 respondents that were interviewed for the study.

3.4 Data Collection

Primary data for the study were obtained from grape farmers and traders, both wholesalers and retailers using separate pre-tested structured questionnaire. The data collected included the socio-economic characteristics of the respondents, the quantity of grape purchased and sold, and the socio-economic factors influencing PHLs of grapes. The individual interviews were complemented with personal observation; focus group interviews and key informants to validate

the information provided by the respondents. District Agricultural Irrigation and Cooperatives Officers (DAICOs), Village and Ward Extension Officers, Village Government Leaders, Research Officers and Ward Executive Officers (WEO), took part in the key informant interviews.

3.5 Data Analysis

Descriptive statistical analysis and multiple regression analysis were used to analyze the collected data. Descriptive statistics which included frequencies, percentages, mean, minimum, maximum and standard deviations were used to analyze the socio-economic characteristics of the respondents and other variables which were entered in the model. Multiple linear regression model as described in equation 5 was employed to examine the socio-economic determinants of post-harvest losses in grapes at farm and traders levels whereby ordinary least square (OLS) technique was used. This model was selected because the dependent variable was a continuous but also because of its simplicity and practicability (Greene, 2012). Thus, from equation 5 above the regression equation at farm level was presented as:

$$LnPHLs = \varphi_0 + \beta_1 lnAgeresp + \beta_2 lnEduresp + \varphi_1 Market + \beta_3 lnQtyhav + \beta_4 lnAgegrp + \varphi_2 Storage + \varphi_3 Credit + \beta_5 lnExpgrp + \beta_6 lnFamsize + V_i \quad (8)$$

Where: ln = Natural logarithm, *PHLs* = Post-harvest loss of grapes at farm (kg/ha for i^{th} farmer), Ageresp = Age of respondent (years), Eduresp= education level of the respondent (years), $\varphi_1 Market$ = market ('1' if unreliable and '0'otherwise), Qtyhav = quantity of grape harvested (kg/ha), Agegrp= Age of grape at harvest (months), $\varphi_2 Storage$ = Storage facilities ('1' if use storage facilities and '0' otherwise), $\varphi_3 Credit$ = Credit access ('1' if had access to credit and '0'otherwise), Expgrp = Respondent experience in grape farming (years), Famsize = Family size (numbers of persons), φ_0 = Constant and $\beta_1, \ldots, \beta_9$ are parameters to be estimated and V_i = Error term. The regression equation at trader's level was as specified below:

$$LnPHLs = \varphi_0 + \beta_1 lnAge + \beta_2 lnEdu + \beta_3 \ln Qtypurch + \beta_4 lnExptrade + \beta_5 lnTimemkt + \varphi_1 Credit + \beta_7 lnDist + \beta_8 lnTimefarm + \varphi_2 Storage + V_i \quad (9)$$

where PHLs = Post-harvest loss of grapes at traders level (kg), Age = Age of the respondent (years), Edu = education level of the respondent (years), Qtypurch = quantity of grapes purchased (kg), Exptrade = experience in grape trading (years), Timemkt = Time grape spent on market before selling (days), $\varphi_1 Credit$ = Credit ('1' if access credit and '0'otherwise), Dist = Distance from farm to market (km), Timefarm = Time grape spent on farm before transported to market (days), $\varphi_2 Storage$ = Storage facilities ('1' if use storage facilities and '0' otherwise), φ_0 = Constant and $\beta_1, \ldots, \beta_9$ are parameters to be estimated and V_i = Error term.

3.6 Description of variables in regression model and effects on post-harvest losses

The factors affecting post-harvest losses of grapes and their expected effects are presented in Table 1.

Table 1: Hypothesized relationships between variables

Variables	Measurement	Expected effect on post-harvest losses
Age of household head	Number of years	-
Education level of household head	Number of years	-
Quantity of grapes harvested/handled	Kilograms	+
Distance farm to market	Kilometres	+
Age of grape at harvest	Months	+
Market	Dummy = '1' if unreliable and '0'otherwise	+
Experience in grape farming/trading	Number of years	-
Storage facilities	Dummy: '1' if use storage and '0' otherwise	-
Credit access	Dummy: '1' if had access to credit and '0' otherwise	-
Time grape spent on market before selling	Days	+
Family size	Number of persons	-
Time grape spent on farm before transported to market	Days	+

4. Results and Discussion

4.1 Socio-economic characteristics of the respondents

The summary on the socio-economic characteristics of respondents are presented in Table 2.

Table 2: Socio-economic characteristics of respondents in Dodoma Municipality and Chamwino District

Variable	n	Minimum	Maximum	Mean	SD
Farmers					
Quantity harvested (kg)	240	300.00	28 000.00	7 701.2917	6 427.36474
Age respondent (years)	240	21.00	90.00	44.8667	13.36043
Family size (persons)	240	4.00	10.00	6.2833	1.96276
Experience (years)	240	4.00	26.00	11.5875	6.57438
Education (years)	240	.00	18.00	7.3458	2.46337
Age grape at harvest(month)	240	4.00	8.00	5.5292	1.00961
Traders					
Age of trader	30	20.00	60.00	39.2667	8.83150
Education	30	0.00	16.00	7.1000	4.32594
Experience	30	1.00	20.00	10.0000	5.95963
Distance farm to market	30	25.00	70.00	46.1667	15.23852
Time grape spent on farm before transported to market	30	1.00	3.00	1.8667	0.57135
Time grape spent on market before sell	30	3.00	14.00	7.2333	2.35889
Quantity purchased	30	500.00	7 000.00	5 911.6667	1 633.36353

SD = Standard Deviation

Results in Table 2 show that, the mean age of grape farmers and traders was 44.86 and 39.26 respectively. This implies that most of the farmers and traders sampled were middle aged implying a good number of workforces in the grape industry in the study area. The findings also revealed that the mean number of years spent in school was 7 years with a minimum of 0 and a maximum of 16 and 18 years for traders and farmers respectively. For 0 it means that some heads of household did not receive any formal education while 16 and 18 years implies that some household heads had completed university education. However, the mean of 7 years implies that most grape farmers and traders had acquired primary school education basing on the Tanzanian education system (Table 2).

Coupled with this is the average family size for the heads of household being 6 and 7 for grape farmers. These results concur with those of URT (2012) which revealed that the average household size in Dodoma ranges from 4 to 6 persons. The sampled farmers had the mean experience of 11.58 years on grape farming, the least being 4 and the highest being 26 years of experience. On the other hand, traders had the average experience of 10 years in grape trading. This implies that majority had enough experience in grape farming and trading which could be used in reducing PHLs (Table 2).

The results showed further that there was a wide variation in the total amount of grapes harvested among farmers, from the lowest (300 kilograms) to as high as 28 tonnes, with the average of around 7.7 tonnes. For traders, the mean quantity purchased was 5.9 tonnes. The mean grape harvesting age and the distance from the farm to the market was 5.5 months and 46.16km respectively. The mean number of days the grapes stayed on the farm before being transported to the market was 1.86 days while the number of days the grapes stayed in the market was 7.2 days (Table 2).

4.2 Credit accessibility and market for grapes

Table 3 shows the respondents' access to credit and to the market for grapes. The results show that among the respondents, only 4.2% of the farmers and 20% of the traders had access to credit in their grape farming /trading activities. All (100%) the farmers interviewed had no reliable market for selling their grapes. About 63.3% of the traders reported unreliable market for their grapes.

Table 3: Respondents response to credit access and market for grapes (Dodoma Municipality and Chamwino District)

Variable	Farmers (n= 240)		Traders (n= 20)	
	Frequency	%	Frequency	%
Access to credit				
Yes	10	4.2	3	20.0
No	230	95.8	27	80.0
Total	**240**	**100.0**	**30**	**100.0**
Reliable market				
Yes	0	0.0	11	36.7
No	240	100.0	19	63.3
Total	**240**	**100.0**	**30**	**100.0**

4.3 Socio-economic determinants of post-harvest grape losses at farm level

Before assessing the influence of different socio-economic factors on grape losses, autocorrelation and collinearity diagnostics were conducted as the major problems in cross-sectional data. It is recommended that the model should be corrected if the Variance Inflation Factor (VIF) exceeds 10 and if Durbin-Watson (DW) exceeds 2.5, which indicates serious multicollinearity and autocorrelation (Mutonyi, 2016). The results gave the allowable VIF which is tolerable (VIF<10) and Durbin-Watson (DW< 2.5) as shown in Table 4 and 5; indicating that the data were free from multicollinearity and autocorrelation problems. This now allowed the analysis of the influence of socio-economic factors on grape losses using multiple regression model. The factors include experience in grape farming/trading, education, age, access to credit, family size, distance from the farm to the market, the time grape stayed in the market before being sold, the quantity of grapes harvested, storage facilities, reliable market and the time the grapes stayed in the farm before being transported to the market.

The results showed that the adjusted coefficient of determination (R^2) for both districts was 0.65 indicating that 65% of the variation of quantity of grapes loss is explained by the specified variables (independent variables included in the regression model). Regression coefficients show that the independent variables have both direct and indirect relationship with the dependent variable (Table 4).

Table 4: Results of regression model on the determinants of grape loss at farm level in Dodoma Municipality and Chamwino District (n= 240)

Variables	Dodoma Municipality			Chamwino District		
	Coefficients	SE	t	Coefficients	SE	t
Constant	6.533***	1.045	6.251	7.055***	0.950	7.428
Age (years)	-0.228	0.139	-1.645	0.029	0.127	0.227
Education (years)	-0.017	0.060	-0.281	0.126	0.206	-0.610
Age of grape at harvest (Months)	0.224	0.204	1.101	0.106***	0.047	2.274
Credit access (Dummy)	0.611***	0.176	3.469	0.524***	0.105	4.969
Quantity harvested (kg)	0.860***	0.151	5.677	0.814***	0.135	6.011
Storage facilities (Dummy)	0.090	0.148	0.609	0.254*	0.149	1.702
Market (Dummy)	0.611***	0.176	3.469	0.681***	0.117	5.832
Family size (numbers)	-0.072	0.053	-1.361	-0.144	0.117	-1.229
Experience (years)	-0.514***	0.154	-3.330	-0.254**	0.095	-2.662
R-square	0.695			0.582		
Durbin-Watson	1.411			1.108		
VIF	1.065			1.153		

*, ** and *** denotes significant levels at (p<0.10, 0.05 and 0.01) respectively. Dependent variable: Ln Quantity of grapes lost (kg/ha)

Findings show that, post-harvest losses of grape was negatively and significantly influenced by experience in grape farming (p<0.01) in Dodoma municipality and Chamwino (P<0.05) as indicated in Table 4. The variable was also significant at p<0.01 when both districts were combined (Table 5) indicating that one percentage change in the years of farmers' experience in grape farming, other factors remaining constant, would decrease the mean post-harvest losses of grapes. This implies that farmers with more years of experience seemed to be good in handling practices, hence the less the post-harvest losses. These results are in conformity with observations made by Umar *et al.* (2015) and Mebratie *et al*. (2015) who found that post-harvest losses of kinnow fruit in Pakistan and banana in Ethiopia were negatively and significantly influenced by experience.

The present findings in Table 4 and 5 showed further that, post-harvest losses were positively and significantly influenced by the quantity harvested (p<0.01). This implies that a one percentage change in the quantity of grapes harvested would increase the mean percentage loss of grapes. This was due to the fact that farmers are not in a position to give full attention and care for post-harvest operations when large quantities of grapes are harvested and hence have higher chances of incurring post-harvest losses. The study findings are consistent with the observations made by Aidoo *et al.* (2014) and Babalola *et al.* (2010) who found that the larger the quantity of tomatoes harvested the higher the chances of losses due to poor handling.

Table 5: Results of regression model on the determinants of grape loss at farm level in both Districts (n= 240)

Independent variables	Coefficients	SE	t	VIF
Constant	7.117***	1.091	6.522	
Age (years)	-0.115	0.133	-0.867	1.023
Education (years)	-0.115	0.162	-0.710	1.039
Age of grape at harvest (Months)	0.597**	0.194	3.082	1.065
Credit access (Dummy)	0.403***	0.103	3.906	1.040
Quantity harvested (kg)	0.450***	0.096	4.666	1.115
Storage facilities (Dummy)	0.310	0.200	1.550	1.028
Market (Dummy)	0.444***	0.100	4.431	1.069
Family size (Numbers)	-0.035	0.054	-0.642	1.047
Experience (years)	-0.528***	0.130	-4.056	1.076
R-square			0.650	
Durbin-Watson			0.879	

*, ** and *** denotes significant levels at ($p<0.10$, 0.05 and 0.01) respectively. Dependent variable: Ln Quantity of grapes lost (kg/ha)

Grape fruits ripen and soften with age; and they are also more prone to mechanical damage with age. The results have shown that an increase in the age of grapes at harvest positively increased the grape losses at $p<0.01$ in Chamwino district. This implies that, a one percent change in the age of grapes after maturity increased the mean percentage loss of grapes in Chamwino than their counterparts (Table 4). This was due to poor road conditions connecting Chamwino district to Dodoma town where grapes are marketed as result buyers start buying grapes in villages within Dodoma municipality.

On the other hand, the age of grapes at harvest positively increased the mean grape losses at $p<0.05$ when the districts were combined (Table 5). This implies that the loss is low for farmers who harvest their grapes based on maturity stage. The results are in line with the findings in a study by Mebratie *et al.* (2015) who revealed that harvesting at the right maturity stage helps to attain fruits quality and hence reduces the chance of spoilage of bananas. In addition, harvesting the fruits at the right maturity physiologically influences its post-harvest performance (Turner, 2001; Folayan, 2013).

The results in Table 4 and 5 show further that unreliable market positively increased the quantity of grapes lost at ($p<0.01$). This means that the higher the chances of acquiring market for grapes at the right time of fruit maturity the lower the mean percentage losses; other factors held constant. Thus, farmers with reliable market are more likely to harvest and sell their grapes at the right time after harvest and avoid post-harvest losses. The results concur with the results by Aidoo *et al.* (2014) who found that unreliable market influenced tomato losses in Ghana. The results are also in line with the descriptive findings from this study which reveal that about 100% of the farmers had no reliable market for selling their grapes (Table 3). Access to credit ($p<0.01$) had also positive influence on the mean grape losses (Table 5). This implies that farmers who had no access to credit were more prone to post-harvest losses because they lack funds for improving their farms and for buying post-harvest technologies that could protect their produce from post-harvest losses. The results are in line with the findings by Bala *et al.* (2016) who revealed that lack of credit contributes to post-harvest losses of rice among farmers in Bangladesh.

4.4 Socio-economic determinants of grape loss at trader's level

At trader's level, three variables were found to have significant effect on losses as shown in Table 6.

Table 6: Results of regression model on the determinants of grape loss at traders level (n=30)

Variable	Coefficients	SE	t	VIF
Constant	5.672**	2.258	2.512	
Quantity purchased	1.427***	0.232	6.148	2.302
Age	1.214	0.707	1.717	1.539
Education	-0.497	0.389	-1.278	1.092
Experience	-0.098	0.305	-0.322	1.589
Distance farm to market	1.140**	0.592	1.927	1.355
Time grape spent on farm before transported to market	0.157	0.431	0.365	1.198
Time grape spent on market before sell	1.055***	0.320	3.296	2.732
Storage facilities (Dummy)	0.074	0.336	0.219	1.367
Credit access(Dummy)	-0.031	0.311	-0.098	1.375
R-square			0.720	
Durbin-Watson			1.742	

*, ** and *** denotes significant at ($p<0.10$, 0.05 and 0.01) respectively. Dependent variable: Quantity of grapes lost (kg)

The results showed that the quantity of grapes purchased/handled, the time grapes stayed in the market before being sold and the distance from the farm to the market positively and significantly affected post-harvest loss of grape traders (Table 6). This indicates that the larger the quantities of grapes bought by traders the higher the mean percentage loss of grapes at traders' level at ($p<0.01$), other factors held constant. This is because large quantities of grapes purchased demands ready market and proper management practices in maintaining quality. Since traders have no storage facilities at their premises, it becomes difficult for them to maintain grape quality, resulting into post-harvest losses. However, these finding are in contrast to the results of some other similar studies by Mbuk *et al. (*2011) and Mebratie *et al.* (2015) who found that the quantity of produce handled had a negative influence on post-harvest losses. This could be due to geographical differences, the crop under study and post-harvest management practices undertaken.

Similarly, the number of days which grapes spent in the market before being sold had significant and positive effect on grape losses ($p<0.01$) (Table 6). This indicates that other factors held constant, the more the days before the harvested grapes are sold, the higher the mean percentage in grape losses; and this was chiefly attributed to poor storage facilities and unreliable market. Similar results are also reported by Mbuk *et al. (*2011) and Mebratie *et al.* (2015) who stated that the number of days in finishing selling showed a positive impact on the proportion of the spoilage of tomatoes and bananas. In addition, produce deterioration rate increases as the time it stays in the market increases (Kader, 2005).

The results showed further that distance from the farm to the market significantly and positively influenced grape loss ($p<0.05$). This implies that the longer the distance it would take for grape produce to get to the market, the higher the mean percentage losses due to congestion of the grape

fruits and building up of heat, other factors held constant (Table 6). These results are similar to the findings by Ayandiji and Adeniyi (2011) on tomatoes that showed high losses of tomatoes with long distance to the market in Nigeria. Ayandiji and Adeniyi (ibid) also emphasized that post-harvest loss could be attributable not only to distance and hassles in transportation but also to the time it takes in transportation because tomatoes are perishable produce.

5. Conclusion and policy implications

The study investigated the socio-economic determinants of post-harvest losses of grapes in the study area. From the empirical findings, it can be concluded that experience, age of the grapes at harvest, the quantities harvested, lack of credit and unreliable market were the factors which significantly influenced grape losses at farm level. At the traders' level, grape losses were significantly influenced by the quantities handled, the time grape stayed in the market before being sold and the distance from the farm to the market. Therefore, socio-economic factors greatly influenced post-harvest losses of grapes in the study area; and thus addressing these factors could reduce grape losses.

Based on these conclusions, it is recommended that intervention by both government and other stakeholders in addressing post-harvest losses of grapes in Dodoma Municipality and Chamwino District should focus on socio-economic factors. The focus should be on the provision of credit that would enable farmers to improve their farms. This would also help farmers to buy modern post-harvest facilities to reduce farmers and traders' dependence on local post-harvest facilities which dominate the study area. In addition, investment in grape processing industries is needed to enhance reliable market for grapes which is the major determinant influencing post-harvest losses and constraints against full exploitation of grape production and marketing potentials in the study area. Finally, investment in post-harvest storage facilities by the government and other stakeholders is essential in the reduction of PHLs at farm and traders' levels.

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