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Research Article

Sesame production and its post-harvest loss: The case of large-scale producers in Kafta Humera district, Western Zone of Tigray, Ethiopia

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ABSTRACT

Regarding post-harvest loss of sesame, this study looked at large-scale growers in the Kafta Humera district of the Western Zone, Tigray region, Ethiopia. Its specific goal was to fill in the study gaps by quantifying post-harvest loss and examining the factors that influence it among large-scale growers of sesame in the Kafta Humera District. To achieve these objectives, the study made use of primary and secondary data from desk reviews and field surveys. Utilising a multistage sample technique, 126 large-scale sesame farmers were identified. The percentages of sesame grain post-harvest loss, calculated using the simple descriptive statistics method, were as follows: harvesting (13.5%), drying (51.5%), un-threshed leftovers (17.4%), piles transportation (7%), storage (4.62%), and cleaning (1.8%). These losses resulted in a loss of 24.6% of the large-scale producer's total production. The total amount of sesame produced, the weather, the mode of transportation, the distance piles travelled, the number of stacking days, the educational level, the distance to the farm, the size of the sesame land, the amount of credit obtained, the income from off-sesame farms, road access, the number of storage weeks, and the management of harvesting and threshing were found to be significant determinants of post-harvest loss for large-scale farms using the multiple linear regression analysis m Based on the findings of this study, it is recommended that large-scale producers be better capacitated by means of improved education, more readily available loans at reasonable interest rates, close farm monitoring, and regular farm visits from well-managed farms. It's also preferable to introduce drying and harvesting technology to reduce post-harvest loss.

Keywords: Kafta Humera, Large-Scale, Loss, Post-harvest, Sesame

INTRODUCTION

Background of the study

The most significant sector of Ethiopia's economy is agriculture, which provides over 85% of the country's livelihoods, employs about 85% of its labour force, contributes roughly 45% of its GDP, and generates about 86% of its foreign exchange (FDRE, 2016).

One of Ethiopia's six priority crops, sesame is an oil seed crop that thrives in semi-arid tropical climates. It is best suited to well-drained, moderately fertile soils with light to medium texture and temperatures between 20 and 35°C (Wijnands et al., 2007).

More than 867,347 small-scale farmers in Ethiopia grow sesame as a cash crop, cultivating 0.42 million hectares and yielding 0.29 million tonnes, while large-scale producers grow 0.28 million hectares and yield more than 0.22 million tonnes (CAS, 2015).

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Nationally, 1.1% of all grain produced and 3.35% of all acreage in the country are devoted to sesame (CSA, 2015). Produced in Welega, Benishangul Gumuz, South Omo, North Gondar, and the lowlands of Western Tigray (which accounted for over 68% of the country's crop) (CSA, 2015). For the national output of 0.687 tons/ha, Amhara, Tigray, and Oromia scored 39%, 29%, and 21% nationally with productivity of 0.66, 0.704, and 0.735 tons/ha, respectively (CSA, 2015).

More than 70% of the country's sesame harvest, or over 90% of the value of oil seed exports, was sold on the foreign market for around 427 million USD, making sesame a commodity that is traded worldwide (FAOSTAT, 2012). Additionally, it was noted that, of the entire production in the 2013–14 crop season, 59% was produced in Amhara and 88.7% in Tigray were supplied to international market (CSA, 2014).

Sesame production in Kafta Humera area was carried out by more than 26,352 small-scale (KHARDO, 2013) and more than 1130 large-scale (KHLAdO, 2015) producers, accounting for 88.7% of the region's total production (CSA, 2014). Sesame holds the majority of the economic importance in the Western Zone of Tigray, namely in the Study District (KHARDO, 2015). Additionally, it employed 370,000 seasonal workers from the SNNP, Amhara, Oromia, and other zones of Tigray (WTZAO, 2014). In terms of sesame area coverage and production, the Tigray region came in second place, according to CSA (2014). With an average productivity estimated to be 0.7 tons/ha, the study area accounted for the majority of the region's sesame area (76.33%) and total production (76%). (CSA, 2015).

Sesame cultivation in the study area requires a lot of labour, particularly when it comes to clearing land, weeding, and harvesting; the cost of temporary labour for these tasks is 1,600 birr/ha for harvesting and 3,150 birr/ha for weeding (AIIC, 2014).

The amount lost between the harvest and consuming stages is known as post-harvest loss. It happens during the entire post-harvest handling process, including packaging, pre-processing, shipping, storing, and marketing. Sesame has a significant post-harvest loss despite being a major cash crop in the western zone of Tigray, especially in the Kafta Humera district where it is supplied to the global market. However, despite the significant loss, no research has, to the best of the researcher's knowledge, been done on the primary causes of post-harvest loss.

Therefore, it is critical to calculate the percentage of loss at each market/supply chain step and to pinpoint the main factors that influence loss both during and after harvest for export.

Given that agriculture is the foundation of the country's food security and that sesame is the second agricultural product that generates foreign exchange and the main crop grown in the study area, a study measuring the amount of grain losses during and after harvest along with its determinants must be carried out in order to propose post-harvest loss reducing mechanisms. Consequently, the research on sesame post-harvest loss in the Kafta Humera district among large-scale growers was created to fill in the gaps in quantifying post-harvest loss and associated.

MATERIALS AND METHODS

The study was carried out in Ethiopia's lowland regions in the Kafta-Humera district's Western Zone Tigray Regional State. Eritrea to the north, Sudan to the west, Tsegedie district to the south, Welkayt district to the east, and North Western Zone to the northeast encircle Kafta Humera district. There are 24 kebeles in the research region, all of which have the capacity to produce sesame. 53,945 men and 49,792 women make up the district's total population of 103,692, living in 26,352 houses on 4,542.33 square meters of arable land (396,852 hectares) (KHARDO, 2013). More than 1,130 large-scale farmers grow sesame in the district, which the government has designated as an investment area (KHLAdO, 2015).

The dark, chromic vertisol soil type in the research area is distinguished by a particularly deep clay texture that makes it vulnerable to water logging during periods of intense rainfall. The region experiences 22.2-42 °C average temperatures and 400-650 mm of yearly rainfall from June to September (Hagos and Fetien, 2011). There is potential for sesame farming in the district; it is a lowland area with an altitude range of 609 to 696 meters (Bereket and Yirgalem, 2012; KHARDO, 2013). The latitude (oN) of 14015' to 13036' and the longitude (oE) of 36037' to 36041' comprise the study area.The research region is well-known for growing a variety of grains, mainly sorghum and sesame. These were the district's principal commercial crops, according to reports from HuARC (2014) and KHARDO (2013).

Along with producing crops, the majority of the district's residents also grow or keep specific breeds of cattle, goats, and sheep. These are known as begait cattle. Four kebeles (Adebay, Baeker, May Cadera, and Rawyian) that produced sesame in the Kafta Humera district were chosen at random by selecting a rolled piece of paper, as shown in Figure 1. These kebeles may serve as a representation of the district's sesame prospective kebeles since they share a common society with respect to culture, economic standing, climatic conditions, agro-ecology, farming methods, topography, geographic layout, soil type, and other factors. These kebeles also have comparable district-level expertise assistance and administrative entities. The average distance from one kebele to the other next kebele is roughly 19 Km.

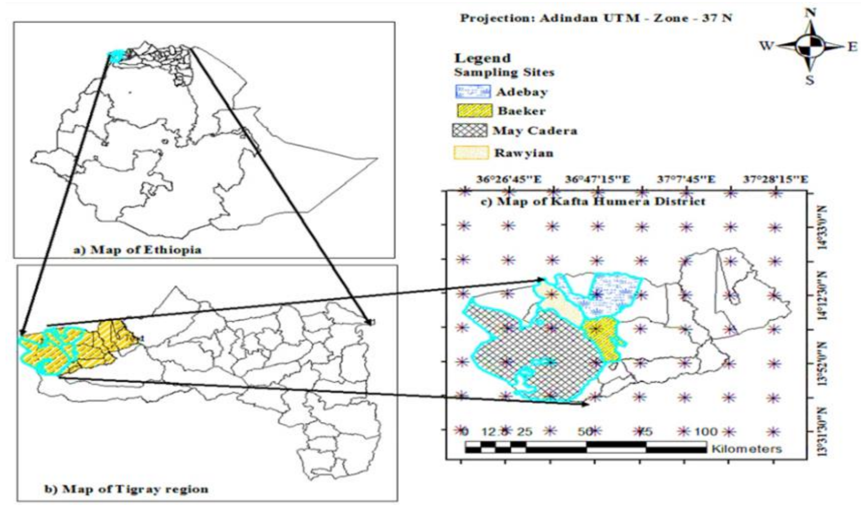

Figure 1. Map of the study area, Kafta Humera district, western zone Tigray.
Source: Own study area map using Arc GIS (2016).

Data types, sources, and collection methods

Cross-sectional data were acquired and used in this study from primary and secondary data sources. The information was gathered through field surveys, field data recording, and a variety of public and unpublished sources. Large-scale producers of sesame in four randomly chosen sesame-producing kebeles (May Cadera, Baeker, Adebay, and Rawyian) provide primary data using rigorous survey processes (Figure 1). Additionally, field measurements were made in these kebeles at every step of harvest and post-harvest management in order to gather data. Those who answered the survey were the respondents who were chosen to participate in the field data collecting on post-harvest loss.

Sample procedure and size

The study selected a sample of large-scale sesame farmers using a multi-stage sampling technique. First, the Kafta Humera district in Western Zone Tigray was specifically chosen due to the district's potential for sesame production and the presence of large-scale sesame farmers there. Second, four kebeles were chosen at random (May Cadera, Baeker, Adebay, and Rawyian) (Figure 1 and Table 1). In the third step, a random sampling technique was used to collect the specified number of respondents, based on the likelihood proportionate to the amount of sesame producing large-scale farmers from each sample kebeles. The following formula, which Yamane (1967) devised, was used to determine the anticipated total sample size. Given a 90% confidence level and an error (e) of 9%, let n be the sample size and N be the total number of household's district that is equal to 1,130. Based on the calculation,126 large-scale sesame producers were sampled (Table 1).

$$n=N/1+N(e^2) \qquad (1)$$

Table 1. Number of sampled small and large-scale producers from each kebele.

Kebele	Total pop.	Sample	Percent
Adebay	98	16	12.7
Baeker	149	25	19.84
May Cadera	409	68	53.97
Rawyian	107	17	13.49
Total	763	126	100

In addition to the respondents chosen for the interview, 40 large-scale growers were chosen at random from those previously chosen for the survey interview in order to gather data on sesame post-harvest loss.

Techniques for analyzing data

Both econometric models and descriptive statistics are used in this study to analyze the data that was gathered.

Sources of Sesame Post-Harvest Loss: The study used both descriptive statistics and multiple linear regression methods to examine the data, depending on the type of data that was available. Since the mean, frequency, and ratio can be used to compare and characterize the quantity or percentage of sesame grain lost, descriptive statistics are useful. In the second instance, the linear relationship between the amounts of sesame grain post-harvest loss and plausible explanatory variables was examined using the multiple linear regression approach variables using the cross-sectional data obtained from large-scale producers. The model is given as:

$$Y_i = \alpha_0 + \alpha_1 X_{1i} + \alpha_2 X_{2i} + \alpha_3 X_{3i} + \ldots + \alpha_{15i}\ X_{15i} + \varepsilon_i \quad (2)$$

Where, i=ith respondent; Ɛ=Random-error Y_i=the post-harvest loss of sesame for the ith producer; α=parameter coefficients to be determined; X_i= 1, 2 …15, explanatory variable of the validity tests of the multiple linear regression model are conducted to determine whether it satisfies the requirements of the OLS, including those related to normality, autocorrelation, heteroskedasticity, endogeneity, and severe multi-collinearity, which prohibit drawing conclusions about the study area's general population. The data was subjected to various tests, including the Breusch-Pagan technique for heteroskedasticity, the VIF for severe multi-collinearity among the variables, the Wu-hausman test of the instrumental variable for endogeneity, and the Ramsey RESET test for omitted variables.

RESULTS AND DISCUSSION

The study's findings are presented and discussed in this chapter. The results of the econometric model and the results of the descriptive statistics are given separately in two sections.

Descriptive statistical results

This section presents descriptive statistics results of sampled households' demographic and socio-economic characteristics, institutional services and inputs used in the econometric models.

Demographic features and availability of production resources

The average family size of large-scale producers, were six persons in each family with the average composition of three by three for male and female members (Table 2).

Table 2. The average household characteristics of large-scale sesame producers.

Variables	Mean
Age (years)	48.4
Experience(years)	19.8
Total family size (No)	6.5
Male family members (No)	3.3
Female family members (No)	3.2
Total active family size (No)	3.9
Total non-active family size (No)	2.5
Dependency ratio	0.38
Education level (years of school)	4.88
Number of extension contact (No)	1.34
Number of training obtained (No)	0.91
TLU	12.73
Off-sesame income amount (Birr)	61,361.27
Amount borrowed money (Birr)	347,960.30
Amount of own income (Birr)	192,245.10

As indicated in Table 2, the average numbers of active and non-active family members of these producers were four and two, respectively. It is also found that the average age of the households is 48 years with an average educational level (in years of schooling) of about five years of schooling. The average sesame production experiences of the sampled large-scale sesame producers were 19.8 years (Table 3). As it is also presented in Table 3, 79 % of the sampled large-scale producers were members of cooperative and 35.7% of them participated in off-sesame farm activities.

Table 3. Gender, membership and off-sesame farm engagement of large-scale producers.

Variables		**Freq.**	**Percent**
Sex of household head	Male	105	83.33
	Female	21	16.67
Membership in association	Member	100	79.37
	Not	26	20.63
Participation in off sesame farm activities	Yes	45	35.71
	No	81	64.29
Application of fertilizer	No	18	14.29
	Yes	108	85.71
Obtaining status of off-sesame income	Yes	81	64.29
	No	45	35.71
Livestock ownership	Yes	68	50
	No	68	50
Living home ownership	Yes	120	95.24
	No	6	4.76
Obtaining status of extension contact	Yes	41	32.54
	No	85	67.46

Labor availability and hiring

All the sampled sesame producers whatever their cultivated land size used hired labor at different stages of their sesame production activities (Table 4).

Table 4. Frequency of sampled producers who used hired labor verses production activities.

Stages at which labor hired	**Freq.**	**Percent**
Harvesting only	0	0
Weeding and harvesting	3	2.38
Land Preparation, sowing and weeding	0	0
Land Preparation, weeding and harvesting	0	0
Weeding, harvesting and threshing	3	2.38
Land Preparation, weeding and threshing	0	0
Sowing, weeding, harvesting and threshing	2	1.59
Land Preparation, sowing, weeding, harvesting and threshing	118	93.65
Total	126	100

As shown in Table 4, from the total sampled large-scale sesame producers 93.65% used hired workers for all production activities (starting from land preparation to threshing) with the total number of 2979 man days per household per year. While, on per-hectare bases, they hired 23 man-days per hectare per year (Table 5). It also shows most of the hired laborers used during weeding followed by harvesting.

Large-scale sesame producers in the study area incurred higher cost for hired labor per-ha in all the major production activities that lead to the average per-hectare labor cost of birr 4137.74 (Table 5).

Table 5. Amount of labor hired and labor cost per hectare for individual large-scale producer in different activities of sesame production.

	Number of labors hired		Labor cost	
Activities	Average	Std. Err	Average	Std. Err
Total/household per year	2979.34	---		----
Land preparation	4.77	0.28	396.1	20.77
Sowing	0.1	0.07	64	5.42
Weeding	13.24	0.67	2183.05	92.41
Harvesting	4.54	0.44	1250.9	34.91
Threshing	0.52	0.05	243.69	6.55
Per household /hectare	23.17 ---		4,137.74 ----	

Land size and ownership

The average land holding size of the sampled large-scale sesame producers in Kafta Humera district was 159.86 hectare of which the 92.76% was obtained from their own; while the remaining 7.24% from rented-in land (Table 6). It is also found that 80.5% and 14.44% of the total land size of large-scale sesame producers is allocated to sesame and sorghum production, respectively (Table 6).

Table 6. Household land holding and allocation of sample large scale sesame producers in Kafta Humera district, 2015/16.

Land source and allocation	Mean	%	Std. Err.
Total land size	159.86	--	28.38
Own land	148.28	92.76	26.66
Land rented-in	11.58	7.2	4.13
Land rented out	0.13	0.075	0.089
Uncultivated land	7.9	4.9	4.6
Sesame land	128.6	80.5	22.42
Sorghum land	23.1	14.44	3.39
Pulses land	0.13	0.075	0.09

The type of sesame seed used and the goal of producing sesame

According to its sequence of application percentage (Table 7), the main sesame seed varieties employed for production by the tested large-scale sesame producers in the study area are Hirhir, Setit-1, bounji, and Gojam azebe. As shown in the same Table, individual large-scale producers consume 437 kg of sesame seed in total, which comes at a cost of 12,681 ETB. Additionally, it is discovered that 98.67% of the total sesame produced by the large-scale farmers in the tested year of 2015–16 was set aside for sale, with the remaining 0.13% and 1.2% going toward seed and household consumption, respectively (Table 7).

Table 7. Mean amount of sesame seed varieties used and Purpose of sesame produced.

Varity of seed used	Mean (Kg)	Percent
Setit-1	34.7	7.94
Hirhir	381.4	87.3
Gojam Azebe	7.23	1.65
Bounji	13.77	3.2
Mean total seed used/household	437 Kg	

Mean total seed cost /household	12,681.64 birr			
Purpose of sesame produced	**Total (Qt.)**	**Mean (Qt.)**	**%**	**Std. Err**
Sold	37284.5	295.91	98.67	0.0013
Seed	48	3.6	1.2	0.0007
Consumption	453.25	0.38	0.13	0.0003

Distance of sesame farm land from residence and mode of transportation used

As it is presented in Table 8, the average distance of sesame farm land from residence of large-scale sesame producers was about 26.66 Km; so that, they visited their sesame farm on average 49 times per the production season.

Table 8. Distance of farm, frequency of farm visit and plough power renting price by sesame producers.

Variables	Mean	Std. Err.
Frequency of farm visit (No)	48.95	1.67
Plough power renting price per hour (birr)	694.8	10.8
Average distance from residence (Km)	26.66	1.25

Off-sesame farm income sources

As it is presented in Table 3, 35.71% of the sampled large-scale producers did not obtain income from off-sesame farm source, while the remaining 64.29% obtained from different sources as in Figure 2.

As it is shown in Figure 2, the highest off-sesame farm income obtained by large-scale sesame producers was from livestock selling (49.51%) followed by renting of tractor (18.91%).

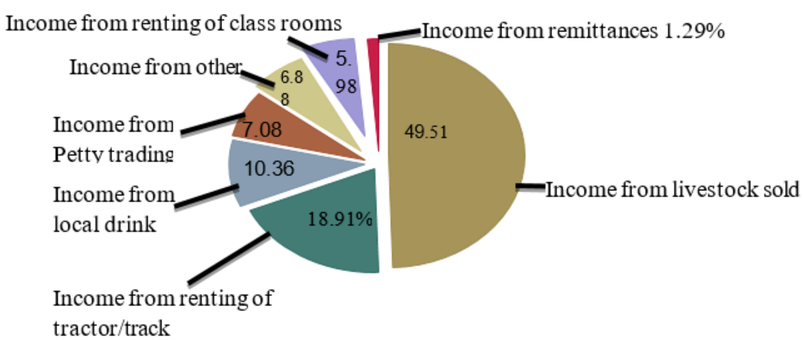

Figure 2. Amount of income obtained from off sesame farm sources by large-scale producers.

Institutional support and services in sesame production

This section discusses the assistance that governmental and non-governmental organizations offer to help sesame growers meet their goals. These services included financial support, trainings, and extension support, all of which will be discussed below:

Regularity of contact with the extension

The extension services were designed to assist, counsel, and direct farmers in increasing yield, attaining food security, and growing commercial commodities like sesame. There were two ways in which the service was rendered in the study district. Firstly, DAs would go to farmers' fields, observe the farms, and offer guidance and remedial measures. The second option is for producers to seek guidance from DAs and FTCs. Tables 2 and 3 show that 67.46% of the large-scale sesame farmers in the sample did not did not obtain any extension advice in 2015/16 production season; while the remaining obtain on average about one contact.

Credit service and its sources

In the study area, there are both formal and informal sources of credit which provide loan for sesame production. The informal sources of credit were traders, friends/parents and other farmers; whereas the formal sources were banks, DCSI and MPP cooperatives. As it is presented in Figure 3, 19.51% of the sampled large-scale sesame producers obtained their unfulfilled financial requirement(loan) from MFIs (DCSI).

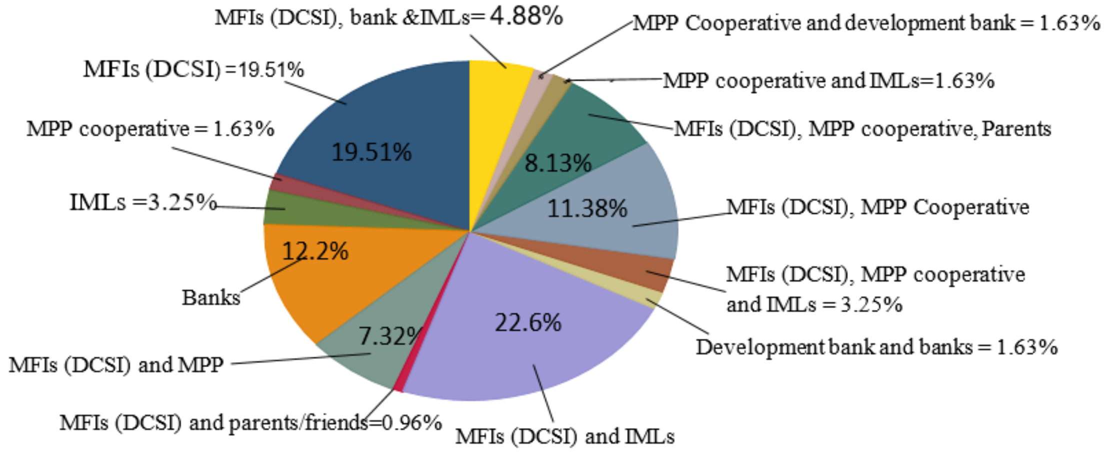

Figure 3. Share of different sources of credit for large-scale sesame producersin 2015/16.

Average yield and cost of sesame production by large scale producers

The average productivity obtained by large-scale sesame producers in the study area was 2.46 Qt/ha at an average production cost of birr 6644.43 per-ha and 2698.68 per-Qt (Table 9).

Table 9. The average yield and cost for large-scale sesame producers.

Variable	Unit	Mean	Std. Err.
Total sesame sown land	Ha	128.59	22.42
Average sesame yield	Qt/ha	2.46	0.07
Average production cost/ ha	Birr/ ha	6644.43	1899.165
Source: Survey result, 2016			

Post-harvest loss of sesame grain

Table 10 shows that, of the total loss, the amount of sesame grain lost during the pile stacking (drying stage) accounts for the largest percentage (51.5%), followed by the loss resulting from remaining unthreshed pods and pods thrown (17.4%). On the other hand, the process of moving sesame from store to market resulted in the least amount of loss (0.07%).

The research area's average sesame grain loss per producer was approximately 73.65 Qt, or 0.57 Qt per hectare. This resulted in a 24.6% loss percentage, or the ratio of loss to total production gained (Table 10). The findings of this investigation are in line with those of Aramyan and Gogh (2011), the FAO (2011), and Tefera et al. (2011), who found the range of loss between 20-40% of the total produced amount. It is also similar with the result obtained by Hodges et al. (2011) that the cumulative post-harvest loss of wheat, sorghum and maize, for Ethiopia was ranging from 15% to 25%. The result obtained also matches with the result of post-harvest loss found by Hodges (2012) for Tanzania to be 22% and for Benin 27% of the total produced amount.

Table 10. The amount of sesame grain loss at different stages from sesame producers.

Stage at which loss occurred	Unit	Mean	Amount Per-ha	Amount Per-Qt.	%
Re-cleaning process loss	Kg	176.03	1.37	0.59	2.4
Loss during selling	Kg	6.42	0.05	0.02	0.087
Transport (from store to market)	Kg	5.5	0.04	0.02	0.075
Loss at storage	Kg	340.7	2.65	1.14	4.6
Loss due to poor quality sack	Kg	8.1	0.06	0.03	0.11
Transport (from farm to store)	Kg	340	0.26	0.11	0.46
Cleaning loss	Kg	131.4	1.02	0.44	1.8

Un-threshed thrown	Kg	1278.3	9.94	4.27	17.36
Threshing loss	Kg	74.8	0.58	0.25	1.01
Piles transport	Kg	522.1	4.06	1.74	7.1
Piles stacking/drying	Kg	3790.6	29.48	12.65	51.5
Harvesting loss	Kg	997.2	7.75	3.33	13.54
Total grain loss	Kg	7365.15	57.27	24.58	100

Sesame did not remain longer in Ethiopia, especially in the Kafta Humera district, in contrast to most other research. This is because sesame is an export product, which lowers storage loss in this study. The largest loss was observed during pile stacking or drying, more likely because of its highly breaking character and prolonged drying time. According to Kaminski and Christiaensen's (2014) findings, over 32% of the world's food production is lost during harvest, with up to 37% occurring in Sub-Saharan Africa. The following will be a thorough study of the loss of sesame grains at each stage of the supply chain:

Sesame grain loss during harvesting

At this point, the standing sesame's useable portion was chopped, gathered, and put in stacks. When the crop reaches maturity that is, when the pods turn brown and the leaves turn yellow and begin to shade harvesting takes place. At this point, the crop's over maturity (opened pods) was the cause of loss. When workers do their work poorly, some of the harvested grain fails and some standing sesame is left uncut (unharvested). In addition to this, producers clarified that in order to determine whether a sesame field is truly mature, it is preferable to harvest the seed while the first three lower capsules or pods have opened. As a result of these flaws, one large-scale producer reported a loss of 997.2 kg (7.75 kg/ha or 3.33 kg/Qt) of sesame grain happened (Table 10). The loss during harvesting stage takes third rank (13.54%) of the stages where sesame grain loss happened. The solution for this might be good management and follow up of workers during harvesting. It is also important to adopt improved non-shattering sesame varieties.

Sesame post-harvest loss during piles drying

This is where harvested (cut) sesame is kept to dry and allow the pods to tear readily (threshold). At this point, the research area's sesame grain loss is caused by weather dangers including wind, rain, and pests like termites, ants, and web worms. The loss of sesame grains was also caused by inadequate stacking performance. The harvested sesame was left to dry for an average of sixteen days. A larger quantity of post-harvest loss occurred during the drying period, when an average of 3790.6 Kg (12.65 Kg/Qt) of sesame grain was lost from individual large-scale farms (accounting for 51.5% of the overall loss (Table 10).

Sesame post-harvest loss during piles transportation

This refers to the transportation of stacked piles from the place where it was piled to the place where it would be threshed. The average distance the harvested sesame moved for threshing was 13 meters. The average amount of sesame grain loss per individual producer in this stage was 522.1 Kg (1.74 Kg/Qt); which accounts for 7.1% of the total loss (Table 10).

Sesame post-harvest loss during threshing

Threshing is the stage in which sesame grain extracted (separated) from sesame pods (capsules). Grain loss was occurred at this stage because of poor performance of threshing workers. According to the study results as presented in Table 10, the average amount of sesame grain loss at this stage per household was 74.8 Kg (0.25 Kg/Qt) that takes the percentage share of 1.01%.

Sesame post-harvest loss due to un-threshed remain pod

This is in reference to the loss that happened when a sesame straw bar was thrown while the seeds were still in the pods. In other words, it is a step in addition to the threshing process rather than a stage in and of itself. Grain may not be able to withdraw during threshing in this subprocess if the pods are not completely dry and tear. Grain loss, however, may also arise from subpar threshing operations that cause grain to stay inside the sesame straw bar. With these justifications in mind, each producer's average loss of sesame grain due to unprocessed remnants was 4.27 kg/ha, or 17.36% of the overall loss (Table 10).

Sesame post-harvest loss during cleaning

Cleaning stage includes winnowing and packaging processes. In this stage loss was resulted due to poor performance, high wind force, and limitation of materials used. Due to these causes the average amount of sesame grain loss from individual producer was 131.4 Kg (0.44 Kg/Qt); with the share of 1.8% from the total loss (Table 10).

Sesame post-harvest loss during storage

Sesame producers in the study area used either standardized store or their home. The standard store could be either rented or their own. The average sesame grain loss during storage for individual producer was 340.7 Kg (1.14 Kg/ha) which take 4.60% of the total loss (Table 10).

Economic analysis of sesame post-harvest loss determinants

Using a multiple linear regression model, this section determines the factors influencing the post-harvest loss of sesame for large-scale growers in the Kafta Humera district. The multicollinearity problem in this model is detected using the VIF test, the heteroskedasticity problem is tested using the Breusch-Pagan test, the omitted variable problem is tested using the Ramsey RESET test, and the endogeneity problem is tested using the Wu-Hausman test.

With an overall mean value of 2.04, the VIF test results for each variable in the model for both groups of sesame producers are less than 10. (Table 11). Additionally, the test result of the Ramsey RESET test utilizing powers of fitted values using degrees of freedom is F (3,102)=2.02 with P>F=0.12, demonstrating that there is no issue with missing variables.

The endogeneity test also reveals that the dependent variable in both categories of sesame producers and the explanatory variable, total sesame output, have a one-way endogeneity issue. Using Instrumental Variables (IVs) and using the Wu-Hausman and Durbin (score) tests is the solution to this problem. Because of this, the average productivity of sesame has been chosen as the instrumental variable in both situations. The model's consistency is demonstrated after use.

The null hypothesis could not be rejected based on the results of the Breusch-Pagan test for heteroskedasticity, since *chi Square* (1) equals 0.59 and the P-value is 0.44. Thus, Table 11 indicates that there was no heteroskedasticity issue, indicating that the model's variance was constant. Besides, the Adjusted R-squared value of 0.95 that imply 95% of the sesame post-harvest loss amount from large-scale producers is explained by the explanatory variables in the model. Taking the model validity tests and proving as the model is valid the study determines the post-harvest loss determinant variables as follows.

Table 11. Determinants of sesame post-harvest loss for large-scale producers.

Variable	Coefficient	Std. Err	VIF
Age (Years)	-0.0024	0.012	1.9
Education level (Schooling years)	-0.013**	0.0057	1.85
Land size (Ha)	-0.05*	0.03	3.89
Distance of sesame farm (Km)	0.05*	0.032	2.22
LnTotal sesame output (Qt)	0.25***	0.03	3.6
Weather condition (Dummy)	0.06***	0.01	2.04
Distance hila transported (M)	0.02***	0.0065	1.82
Days stored (No Week)	0.005*	0.003	1.48
Road type (Dummy)	-0.10***	0.028	1.65
Number of extension contact (No)	-0.006	0.02	1.79
Lnloan obtained (Birr)	-0.04*	0.0198	1.8
Lnoff sesame income (Birr)	-0.02***	0.0086	2
Threshing management (Dummy)	0.078**	0.0378	1.56
Days staked (Days)	0.04**	0.018	1.53
Mode of transportation (Dummy)	0.11***	0.037	1.57
Constant	0.52	0.885	
Mean VIF			2.04
Adj. R-squared	0.9495		
Het test (test for Heteroscedasticity)	$Chi^2(1)=0.59$,		Prob.=0.4412
Ov test (test for Omitted variable)	F (3, 102)=2.02		Prob. >F =0.12
*, **, *** indicates the significance level of the variable at 10%, 5%, and 1% respectively;			

Based on the results presented in Table 11, several factors significantly impact post-harvest loss in sesame production. These factors are categorized into demographic, socio-economic, farm attributes, and institutional factors. Below is a detailed discussion of each significant determinant, with an emphasis on the assumption that other variables are held constant, and considering the existing technology and time period.

- **Education Level of the Household Head (EDUHHD):** The education level of the household head has a significant negative effect on post-harvest loss at the 5% level. Specifically, each additional year of schooling is associated with a 1.3% reduction in sesame grain loss. This effect may stem from the enhanced management and operational skills that come with higher education. This finding aligns with the results of Basavaraja et al. (2007).

- **Land Size (LANDSZ):** Land size significantly affects post-harvest loss at the 10% level. An increase of one hectare in land size results in a 0.05% decrease in post-harvest loss. This relationship could be attributed to the fact that larger farms often employ multiple managers who improve the oversight and management of harvesting and storage.
- **Distance of Sesame Farm from Residence (DISTFH):** This variable is significantly and positively associated with post-harvest loss at the 10% level. A one-kilometer increase in distance between the farm and the residence leads to a 5% increase in loss. The increased distance may result in less effective management of harvesting and storage, as well as higher losses during transportation.
- **Total Sesame Production in 2015/16 (LNTSSY):** Total production is a significant positive determinant of post-harvest loss at the 1% level. A 1% increase in total production corresponds to a 25% increase in post-harvest loss. This may be due to challenges in managing larger quantities and limited storage capacity, which exacerbate losses.
- **Weather Conditions (WEAZER):** Weather conditions have a significant positive impact on post-harvest loss at the 1% level. Adverse weather, such as wind and rain during the harvesting and threshing periods, increases post-harvest loss by 1.2%. This finding is consistent with Basavaraja et al. (2007).
- **Distance of Piles Transported to Threshing Place (DISTHILA):** This variable significantly affects post-harvest loss at the 1% level. For each additional meter of transport distance, post-harvest loss increases by 2%. Longer transport distances may lead to higher losses due to handling and potential spillage.
- **Number of Sesame Storage Days (WEEK):** The number of storage days has a positive and significant relationship with post-harvest loss at the 10% level. Each additional week of storage results in a 0.45% increase in loss. Extended storage periods can lead to issues such as pest infestations and moisture loss.
- **Road Infrastructure Availability (ROADFH):** Access to road infrastructure significantly reduces post-harvest loss at the 1% level. Availability of roads decreases loss by 10.4%, likely due to improved transport and access to markets.
- **Credit Obtained (LNLOAN):** Credit access significantly influences post-harvest loss at the 10% level. Each 1% increase in loan amount corresponds to a 3.6% decrease in post-harvest loss. Credit can facilitate timely and effective management practices, reducing losses.
- **Off-Farm Income (LNOFFINC):** Off-farm income negatively impacts post-harvest loss at the 1% level. A 1% increase in off-farm income leads to a 2.4% decrease in post-harvest loss. Higher income allows for better management and resources for handling sesame.
- **Harvesting and Threshing Management (THRMGT):** Poor management of harvesting and threshing significantly increases post-harvest loss at the 5% level. Careless practices lead to a 7.8% increase in loss, highlighting the importance of careful handling.
- **Number of Stacking Days (DAYSTAK):** The number of stacking days is positively related to post-harvest loss at the 5% level. Each additional stacking day increases loss by 1.8%, likely due to increased exposure to pests and environmental conditions.
- **Mode of Sesame Grain Transportation (MODTRSFH):** The mode of transportation significantly affects post-harvest loss at the 1% level. Using a donkey for transportation reduces loss by 11.2% compared to using a tractor. This may be due to better individual attention and care during loading and unloading with donkeys.

Future policy directions

To mitigate post-harvest loss in sesame production, the following policy directions are recommended:

Technological improvements: Introduce technologies to enhance drying, transporting, and protecting sesame from weather and pests. This can significantly reduce post-harvest losses.

Management and education: Encourage effective farm management practices and improve educational opportunities for producers. Education has been shown to reduce losses, and better management can address issues related to production scale and transportation.

Infrastructure development: Enhance road infrastructure to facilitate better transport of sesame, thereby reducing losses associated with poor road access.

Credit and financial support: Increase access to timely and affordable credit to enable producers to manage their operations efficiently and reduce losses.
Income diversification: Support off-farm income opportunities for producers, as additional income can improve their ability to manage sesame production effectively.

Training and support: Provide training on best practices for harvesting, threshing, and storage to reduce post-harvest losses. Implementing these measures can help address the factors contributing to sesame post-harvest loss and improve the overall efficiency and profitability of sesame production.

CONCLUSION

In conclusion, addressing post-harvest losses in sesame production within the Kafta Humera District is crucial for enhancing profitability and sustainability. Implementing improved storage, handling practices, and stakeholder collaboration can significantly reduce losses, ensuring better quality and increased economic benefits for large-scale producers in the region.

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